AN ESSAY

ON THE

PRIMITIVE UNIVERSAL STANDARD

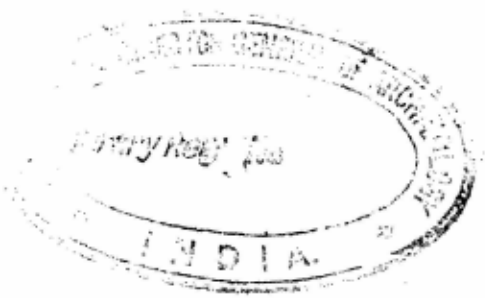
OF

Weights and Measures.

BY

CAPTAIN T. B. JERVIS,

BOMBAY ENGINEERS.



RECORDS

OF

ANCIENT SCIENCE,

EXEMPLIFIED AND AUTHENTICATED

IN THE

PRIMITIVE UNIVERSAL STANDARD

OF

Weights and Measures.

COMMUNICATED IN AN ESSAY TRANSMITTED

TO

CAPT. HENRY KATER,

VICE-PRESIDENT OF THE ROYAL SOCIETY.

BY

CAPTAIN T. B. JERVIS,

OF THE ENGINEER CORPS.

"I applied mine heart to know, and to search, and to seek out wisdom, and the reason of things, and to know the wickedness of folly, even of foolishness and madness:—

"Lo, this only have I found, that GOD hath made man upright, but they have sought out many inventions."

[*Ecclesiastes, Chap.* vii. *vers.* 25 *and* 29.]

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PREFACE.

Ἀρχὴ φιλοσοφίας συναίσθησις τῆς αὐτοῦ ἀσθενείας, καὶ ἀδυναμίας περὶ τὰ ἀναγκαῖα.—*Epictet. Arrian.*

"The consciousness of one's own weakness and incapacity in matters of the greatest concern, is the beginning of *True* Philosophy."

It is not improbable that the following particulars would never have met the public eye, but for the accidental perusal of an article in the 31st No. of the Westminster Review, for January, 1832, entitled, A Review of Introductory Lectures on Political Economy, being part of a course delivered in Easter term, 1831, by Richard Whately, D.D. Principal of St. Alban's Hall; Professor of Political Economy in the University of Oxford.

In looking over some numbers of this periodical at the house of a friend, I observed an article on weights and measures, which attracted my attention, the more particularly as I was then engaged in researches on that subject. In a leisure hour I glanced over the first article also, in which the reader may find the following remarkable observations:

"The fifth lecture contains a disputable theory, but one that only remotely involves any practical inferences. The theory alluded to is, that men never did, nor can raise themselves, from a state of complete barbarism, without instruction and assistance from people already civilized; from which it is concluded, that civilization must have been the effect of a supernatural revelation made to some portion of the human species, and that all savages must originally have degenerated from a more civilized state of existence. Of this degeneration, the Lecturer thinks there is little reason to doubt, that the principal cause has been war. Objections may be urged to the theory, without questioning any of the authorities to which the author refers. The only notices of arts, furnished by the record of Genesis, (as noted by the author, in page 139,) consist of two, the working of metals, and the construction of musical instruments; and in neither case is there any intimation of supernatural instruction. Some appearance of an opposite nature might be held to be contained in the mention made of coats of skins; but the author has not considered this as ground whereon to found an argument. If

knowledge came originally by inspiration, the chosen race contrived to carry away very little of the benefit. The inhabitants of Egypt had far outstript them, when their patriarchs entered that house of bondage; or Moses would never have been celebrated as learned in all the wisdom of the Egyptians. Many ages afterwards, Solomon, or his historians, knew no nearer proportion of the circumference of a circle to the diameter than that of three to one. (1 Kings vii. 23; and 2nd Chron. iv. 2.) There was no necessity for saying what the circumference was at all; and a writer who had known that the circumference of a circle of ten cubits diameter was, on a rough estimate, thirty-one cubits and a half, would never have volunteered asserting it was thirty. It is scarcely credible that a native of New Holland should not know that the girt of a tree is more than three times its thickness. Whatever Solomon might have done for Botany or Zoology, it is clear he had not done much for the geometry of his subjects."

Probably some of my readers will be reminded, after the perusal of the foregoing and subjoined interpretations of the very same

passages of Scripture, of that steady practised attention which is necessary to the performance of minute optical or chemical experiments, and the timely perception of their results; for like those dark lines seen in the solar spectrum by Frauenhofer, the real beauties of Scripture require to be beheld in certain positions;—the observer must be instructed "*how to see them**." Now the true account of the matter is briefly this:

The sacred Scriptures incidentally describe a brazen vessel, which was of an oblate spheroidal form, the dimensions, (which are stated in measures, which our English version translates cubits,) being the 72,000,000ths of the earth's polar circumference, the capacity divided by 2,000, gives the content of the Jewish *bath*, or *epha;* six times which quantity gives the cube of the Jewish cubit, or *amma;* and double the cube root of this cubic cubit, the mean length of the second's pendulum, or pendulum which vibrates 86,400 times in a mean solar day, at the level of the ocean, in

* Babbage on the Decline of Science in England; contrast of Dr. Wollaston's and Sir Humphry Davy's Philosophical Characters.

latitude 45°, at the temperature of 39½° of Fahrenheit's scale, in vacuo.

This pendulum, divided into 48 parts, or 28 parts, furnishes an exact explanation of all linear measures throughout the world in all ages.

This pendulum cubed, and divided exactly as in the preceding case, into 48 or 28 parts, furnishes an exact explanation of all measures of capacity throughout the world in all ages.

This pendulum cubed, and multiplied into the weight of a cubic inch of distilled water, at the maximum of density 39½° of Fahrenheit, each cubic inch weighing 252·984 grains Troy; divided as above into 48 or 28 parts, furnishes an exact explanation of all the weights of whatever kind, whether money or gross weight, throughout the world in all ages.

Lastly, the 200,000ths of a degree on the meridian, in latitude 45°, or the 72,000,000ths of the earth's polar circumference, furnishes the basis or element of itinerary and superficial measure, throughout the world in all ages; and this element is identically the same as that used in the construction and computation of the molten sea of Scripture, from which the linear standard, or mean length

of the pendulum is deduced; being in the ratio of 5 to 9, with respect to the forty millionth of the earth's meridional circumference, in the ratio of 5 to $2\sqrt{20}$, with respect to the mean length of the second's pendulum, both at the temperature of $39\frac{1}{2}°$ of Fahrenheit's scale.

The following account of this curious question may probably enable those who have not yet seen it in the same light, to discover the same or greater evidences of wisdom, design, and truth. The argument, as it affects the excellency and integrity of the original text of Scripture, is one thing; its application to the discovery, understanding, and correction of abuses in the Metrological and Monetary systems of all nations, is scarcely less momentous than the former. The philanthropic Budæus is thought to have dreamed over an Eutopian prospect, when he described the blessings that would attend an uniform and universal currency, and weight and measure,

"Una fides, pondus, mensura, moneta sit idem,
Et status illæsus totius orbis erit."

But what if the system here described is founded in fact? what if mathematically and practically true? the conclusion will be, not

that nothing has a greater tendency to grow worse, or more obstinately resists improvement:—but that no matter of so great and universal interest has a greater tendency to retain its original character and construction; nothing, in short, so obstinately resists innovation, and the substitution of human devices for Divine laws, as weights and measures.

What, for example, will be said of a system that provides a perfect corrective for the Metrology of England, France, and India? In regard to England and France, it will be clearly seen, that the discarded measures, (say for instance, as notorious proofs, *the measures of capacity*,) are founded on the strictest and most scientific principles, and that there was therefore no necessity to alter those in use, which, to quote the reasons of the British commissioners to the legislature, have the prescriptive sanction of long usage, and require adjustment and conformity to some known standard, rather than any positive alterations. In these cases, it was sufficient to have established the true length of the pendulum, taken at a mean throughout the globe, and the law of its expansion and contraction, and the specific gravity of water at its maximum of density,

to *regulate* all the monetary and metrological rules of both countries:—it was sufficient to have determined the forty millionth of the earth's polar circumference, to have corrected and defined the itinerary and superficial measures of both. What would have ensued on referring the ancient schemes to such physical investigations? Not the discontent, and murmurings, and objections of the French people, not the suggestions of every self-inaugurated political economist, but uniformity, exactness, comprehensibility; an amelioration of great and certain evils, by simple, unquestionable, and incalculable benefits. The result would have been, that all foreign nations, all their colonies at least, would have adopted the same principles, and every man would know when he bought or sold, how much he gave and how much he got for a certain sum.

The peculiar gain and honour that would redound to our Indian Governments, by the first introduction of this exact standard, is clear and certain: all the methods of meting and selling might remain in statû quo—the *hat'h* and the *guz*; the *pharra* and the *kundee*; the *garce* and the *murcal*; the *mun* and the *seer*; the *beegah* and the *kos*, might retain

all their old names, provided they were regulated and defined by the mean length of the pendulum; the weight of water at a maximum of density; and the metre or forty millionth of the earth's polar circumference. A British, a French, an American, or in fact, any merchant, might then transact all his business on sure and intelligible data, known and observed by all these nations; and the Indian Government would be protected against innumerable frauds in the intermediate transactions of the revenue:—the poor unlettered *ryot*, or cultivator, the needy and despised heathen, discover, that in depriving the designing of the power and himself of an example to corrupt dealing, the Divine Being had indeed sent a Christian people to direct, to preserve, and to bless them.

There is yet a third question on which the subject bears; general literature, and history: the first without a professed and useful object, is a gewgaw for grown-up children; but history, the history of man; of the progress of intellect, of society, of the powers and propensities of immortal beings, is of infinite concern. We must dethrone every high thought however before we can arrive at knowledge;

and the knowledge of ourselves will be seen best in the mirror of past ages, in the course of human events, to which the seal of confirmation is irrevocably set, without room for further cavil, or possible mistake. In that history we have sufficient examples to instruct us in every thing that can conduce to our comfort here, and our happiness hereafter. To conclude; whether this Essay be taken up by the Christian, the statesman, or the historian, it is to be hoped, that it will obtain a patient and impartial consideration; that what is advanced may be received, so far only as it consists with truth; that it may be reprobated and forgotten where it militates either against fact, experience, or utility.

T. B. JERVIS.

ESSAY

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Nunquam ita quisquam bene subductâ ratione ad vitam fuit,
Quin res, ætas, usus semper aliquid apportet novi,
Aliquid moneat ; ut illa quæ te scire credas, nescias,
Et quæ tibi putâris prima, in experiundo ut repudies.
TERENT. *ADELPHI, Act. 5, Sc. 1-2, ad initium.*

THE difficulty of dislodging prejudices, engendered by false or imperfect principles, has always been found the greatest obstacle to the communication of truth. Conclusions addressed to the mind or senses, although worthy of universal reception, are too frequently seized upon by the fancy, sometimes wrested, but much oftener abused, to the increase of pride, or the detriment of knowledge. And so it fares with that which is pre-eminently excellent, till perchance experience, or time, or conviction, disciplines the understanding to the perception of error,

and discovers the futility of reliance on its own unassisted resources.

Historians and philosophers in general allege that science and art are the creation of the human intellect; that they came by inspiration appears indeed the more problematical, because the evidences to this effect are infinitely less obvious than the arguments for the contrary opinion are plausible. Whether this or that be a prejudice remains to be proved: it is plain, however, that no prejudice can consist with truth; wherefore one or other must be repugnant to sound reason: if then it can be demonstrated, that science subsisted when as yet that very history and philosophy which affirms it to be of human original was not created, we are free to believe that it came by inspiration, or, which amounts to the same thing, that the elements of science, the legitimate uses to which they were applicable, and the faculty to appreciate, improve, and extend them, were imparted to our forefathers by the Supreme Being. Among other interesting and notable proofs of the truth of this position, the following may be selected; they appeal in fact to the utmost range of historical evidence, they bespeak likewise the highest refinements of mathematical skill, and for these reasons, are peculiarly suited to illustrate the latter hypothesis: 1st. That the metrological systems of all nations, throughout the earth, had a common original. 2ndly. That the true standard or prototype is discoverable from certain passages of Holy Writ. 3rdly. That this

primitive universal standard is the mean length of the second's pendulum throughout the earth.

It may be proper to state, that I had made this subject my particular study, independent of the question at issue, and came to it therefore prepared with a great variety of examples and arguments: with these I have illustrated each statement, sparingly, though perhaps sufficiently for its confirmation. To go through the laborious details by which I was led to the knowledge of these matters, would be uninteresting and superfluous. From a diligent examination of the opinions of Drs. Bernard, Cumberland, Greaves, of Danville, Sir George Shuckburgh, Bailly, as well as the more recent compilations of modern authorities, brought under one view in Tillet's Tables, and Dr. Kelly's valuable Universal Cambist, I felt a conviction that no one had ever yet formed a correct estimate of the true length of the first fundamental measure, so appropriately designated by the Hebrews and Patriarchs of old, *Amma*, or the mother of measures of every denomination, which term, in all the translations of scripture, is rendered by the word cubit, or its synonymes.

Having been furnished by the public authorities, under the Bombay Presidency, with every sort of official and well-authenticated information, that could be procured from the Government records; and through the friendship of the late James Joseph Sparrow, Member of the Council, with a very full opportunity of ascertaining the exact dimensions of

those in use throughout the Konkun*, the deductions were all to this effect, that the true cubit was a measure of about nineteen and a half inches English ; that land measure was also grounded on this same linear standard ; moreover, that all measures of capacity were derived from the cube of this cubit, its multiples and aliquot parts ; lastly, that weights, and in connection with them, the weights of all ancient and modern coins, were likewise referrible to the weight of the like quantity of rain or distilled water —its multiples and aliquot parts ; but whence, or at what period, this system was introduced, neither ancient tradition, or literature, whether Hindoo or Mahomedan, nor even the most learned Brahmins or Mahomedans themselves, could afford me the slightest intelligence.

Engaged by the remarkable simplicity and characteristic skill, thus discernible in the first elements of the metrological system of Western India, I followed up the pursuit in respect to those of other parts of the world. By the singular liberality of the Right Honorable Sir Frederick Adam, who is now at the head of the Madras Government, and of the Right Honorable Sir Robert Wilmot Horton, the Governor of Ceylon, I was furnished with copies of every document that could be obtained from the public records and other sources, relative to the weights and mea-

* A province on the north-west coast of peninsular India, subordinate to the Bombay Government.

sures of Southern India, throughout the dependencies of the Honorable East India Company and the Crown. With regard to Northern India, and the Presidency of Bengal, I obtained every thing desirable from parliamentary and other public documents, from the revenue and judicial selections, printed by authority of the Court of Directors of the East India Company, besides sundry manuscript and published particulars: the conclusions, therefore, as respects India generally, are drawn up from the very best possible sources of information, and so far as reliance can be placed on written testimony, are deserving of the public attention.

The sum of these investigations, as respects every local and general usage throughout India, or elsewhere, is very much of the same nature, and is best to be learnt from the standard itself. I shall therefore confine myself to an account of the second and third parts of the subject, then shew how these bear on the first, and finally the great beneficial uses to which the results may be made subservient.

In the curious buildings of the Temple of Solomon, there is the strongest presumptive evidence for the belief, that two distinct linear measures were had recourse to, the one being the very pendulum of which we are in search. (See 2 Chron. chap. iii. ver. 3.) This opinion being founded on the significant import of the Hebrew text, *Ha orek ammoth bammiddah ha reeshonah:* the last word is rendered in the Septuagint, η πρωτη, the English translation thus ex-

presses it: "the length by cubits after the first measure;" the very existence however, of this measure might, but for what is given in the sequel, be considered purely speculative and problematical. The other is conformable to the reputed Egyptian or royal Babylonian cubit, which has been ascertained by reference to many remarkable criteria, as the annual rise of the Nile, the base of the great Pyramid, &c., to be equivalent to 21·874675 inches English nearly.

Among the vessels of the same temple, the most remarkable was the one denominated the molten sea, the description and dimensions of which have furnished sceptics with matter for some very smart reflections, as no very apt illustration of the far-famed wisdom of Solomon; and covertly throwing out a pitiful insinuation as to the inspiration or authenticity of the sacred volume itself. The two passages, descriptive of this molten sea, seemingly involve a contradiction, which has been too long allowed to pass uninvestigated in those venerable seminaries of learning, where mathematical knowledge of the highest order goes hand in hand with a study of the Hebrew, the classic, and oriental languages; yet it is not presumptuously imagined, that the explanation hereunder offered, may not be far better given by those who have grown grey in such studies, and have access to materials, and books, and talented mathematicians—advantages, in fine, that could never be expected in so very remote a place as this, and at the hands of one, who, to the profession of a Military

Engineer, labours under the same disqualifications of an imperfect education, in those departments of science, essential to its explanation.

The two passages are as follows : "And he made a molten sea, ten cubits from the one brim to the other : (Hebrew, "from his brim to his brim ;") it was round all about, and his height was five cubits, and a line of thirty cubits did compass it round about."—"And it was an hand breadth thick, and the brim thereof was wrought like the brim of a cup, with flowers of lilies : it contained two thousand baths."—1 Kings, chap. vii. ver. 23 and 26.

The second passage runs thus : "Also he made a molten sea, of ten cubits from brim to brim : (Hebrew, "from his brim to his brim ;") round in compass, and five cubits the height thereof ; and a line of thirty cubits did compass it round about." —"And the thickness of it was an hand breadth, and the brim of it like the work of the brim of a cup, with flowers of lilies ; and it received and held three thousand baths."—2 Chron. chap. iv. ver. 2 and 5.

The well-known ratio of the diameter to the circumference of a circle is certainly calculated to impeach the above statement on a careless and hasty perusal, but to affect the mind far otherwise, if apprehended rightly as a mathematical representation of a vessel, the content whereof may be readily ascertained from the three dimensions therein given. It now remains for the sceptic to disprove, by the

doctrine of probabilities, that the elements of a system perfect in the highest degree, and applicable in all cases, and under all circumstances and conditions of society, whether simple or refined, whether limited or extensive, should be incidentally elicited from sundry scattered passages in any book of ancient laws, and yet have had no real existence before those laws were promulgated: when moreover traces of this system are clearly discernible throughout all ages, among the systems of all other nations whatever, of which no possible account could be given, without reverting to that code, its history, scope, and design. I neither beg the question, that this is an inspired book from beginning to end; nor do I, although on both these points my own mind is fully made up, insist that the Hebrew text, as we now possess it, has not undergone any material alterations; but affirm, on the plainest rules of argumentative analysis, and sound reasoning, that the internal evidences of its accuracy are irresistibly conclusive.

The vessel in question, therefore, was of an oblate spheroidal form; that is, the half of a solid, generated by the revolution of an ellipse on its conjugate axis, the conjugate remaining fixed, because the depth is stated to be half the length of the transverse: the mutual relation of the periphery, transverse diameter, and depth, to the content and conjugate, implying as perfect a knowledge of the ratio of the diameter to the circumference, as we now possess. For, let t denote

the transverse diameter = 10 cubits; p, the periphery = 30 cubits; c^* = 3·14159265358979+; and x, the conjugate, or fixed axis, then $x = t - \frac{4p}{c} + 4\sqrt{\left(\left(\frac{2p}{c} - t\right) \times \frac{p}{c}\right)}$; = 9·087698466896+ cubits: again, denoting this by f, the revolving axis of ten cubits by r, the capacity of the molten sea will be = ·261799387799149 $fr^2 \times 21{\cdot}874675^3$ = 2492075·37296 cubic inches English measure, the two thousandth part whereof gives 1245·1377 cubic inches English for the content of a single bath.

Now, although at first sight, the two passages appear to involve a contradiction in terms, the English rendering implies, somewhat indistinctly, that nice critical discrimination which is observable in the context: in the one instance, it is said "it contained two thousand baths, *Shoshan alfayim bath yabil;* where we find," "it contained," *yabil;* in the other, "it received and held three thousand baths," *Makhzik bathim shlosheth alfim yabil;* where another expression, *makhzik,* "it received," is superadded to *yabil,* "it held." The first of these, namely, *makhzik,* (like all primitive words,) is derived from a root of a very determinate signification, *khazak,* "to hold," "to contain," "to oblige," "to stay," "to overpower," "to prevail over:" (see the

* The difference between the approximate and exact ratio of diameter to the circumference, though exceedingly inconsiderable in ordinary computations, would, if neglected in the present instance, affect the length of the pendulum so much, as to invalidate the argument, and is therefore an additional proof of its conclusiveness.

original passages, 1 Sam. chap. xvii. ver. 50; 2 Sam. chap. xxiv. ver. 4; 1 Chron. chap. xxi. ver. 4; and many others,) intimating something heaped up, and that the quantity so heaped was the utmost that could be retained. The first instanced therefore was a liquid measure of two thousand baths; the second, a dry measure of three thousand baths: the contents of both, as enjoined in other parts of Scripture, notwithstanding the dry and liquid measure, were discriminated by distinct names, being founded on, or referred to a common principle. "The *ephah* and the bath shall be of one measure, that the bath may contain the tenth part of an *homer*, and the *ephah* the tenth part of an *homer*, the measure thereof shall be after the *homer*." Ezekiel, chap. xlv. ver. 11; lastly, Dr. Cumberland has shewn in the 16th vol. of the Philosophical Transactions of the Royal Society for 1685-6, that the Jewish *ephah* or bath was the sixth part of the cubic cubit, (in his Essay he calls it one-sixth of the Jewish cubic cubit:) now, six times the above quantity, or 1245·137686* × 6 is 7470·8261188813 cubic inches English measure, or the cube of the cubit, the cube root whereof is 19·548925 inches English.

But by Captain Kater's recent experiments, the length of the pendulum, which vibrates seconds, or 86400 times in a mean solar day, at London, in latitude 51° 31′ 8·4″ in vacuo, reduced to the level of the sea, was found to be 39·13929 inches of Sir George

* The content of the ephah, or bath, determined from the molten sea of Solomon's temple.

Shuckburgh's scale, at the temperature of 62° Fahrenheit: comparing this with the principal observations elsewhere, the mean length in latitude 45° may be considered = 39·1163 inches: recourse being had to Captain Sabine's table, published in the 2nd volume of the Philosophical Magazine, (No. 9, September, 1827, page 177;) Biot's Observations Geodesiques, pages 441, et sequent.; and Professor Carlini's Experiments on Mount Cenis, Ephemeride di Milano (for 1824;) Quarterly Journal of Science and Arts, (volume 2nd new series.) The double of the above cubit is equal to 39·09785 inches, being only 184 ten thousandths of an inch in defect of the mean length of the second's pendulum, in latitude 45°, from actual experiment; a defect which may depend on the force of gravity, or some such delicate minutiæ, attendant upon atmospheric pressure, temperature, and the laws of attraction.

The relative proportion of the heaped or dry measure, over and above the liquid contents of the molten sea, was therefore as one to two; precisely in conformity to that property of the cone and sphere, first demonstrated by Archimedes; the true analogy of the diameter and circumference, the nature and properties of the ellipse, are likewise indispensably mixed up with these preliminary computations. Now $\frac{fr^2 \times p}{12}$, expresses the capacity of the oblate spheroidal vessel, or 237·913368 cubic cubits, as does $\cdot 7854 \times fr$, the area of the elliptic base of the conoid;

and because the solidity of the heaped measure exceeded the liquid contents by one-half this last quantity, three times $\frac{f r^2 p}{12} \times \frac{1}{2} \times \frac{4}{f r p}$ or cancelling the common terms, $\frac{r}{6} \times 3 = \frac{30}{6} =$ five cubits, expresses the height of the cone, which thus turns out to be a right angled elliptic cone, (if I may venture this definition of a solid forming part of a right cone,) and this height corresponds to the maximum of altitude, to which wheat, the grain specified in the same chapter of Ezekiel, could be heaped up in a vessel of the dimensions instanced.

Before we quit this part of the subject, let it be observed, that with the nice refinements of modern science, a cubic inch of distilled, or rain water, in the atmosphere, at 62° of Fahrenheit, when weights of brass are used, has been found to weigh 252·458 grains troy; in vacuo, 252·72 grains; as declared in the third and last report of the British Commissioners to His Majesty, dated 31st March, 1821. Now the expansive force of water, according to Dr. Young's catalogue raisonnée, Natural Philosophy, vol. ii, page 391, from a collation of experiments by Gilpin, Kirwan, and Achard, reckoning the 39th degree of Fahrenheit the maximum temperature of greatest density, is expressed by $22 f^2 (1 - \cdot 002 f)$ in ten millionths, (where f denotes the difference of temperature:) in the present case, I reckon the ratio of the expansive force from $39\frac{1}{2}$ degrees Fahrenheit to 62°,

(in vacuo,) as one to 0·998956; the cubic inch of water therefore is equal to $\frac{252{\cdot}72 \times 10{,}00000}{0{\cdot}998956} =$ 252·984 grains troy. Dr. Young estimates it a little less, or 252·980 grains troy. Therefore, the weight of a cubic inch being reckoned 252·984 grains troy, multiplied into 1245·1377 cubic inches, is equal to 315000 troy grains, which corresponds to 720 Roman ounces of the ancient account, each of 437·5 grains troy; 60 Roman pounds of 12 ounces, each of 5250 grains troy; or lastly, 45 lbs. ancient English avoirdupoise account, each of 7000·0 troy grains, the pound of sixteen ounces, each ounce, as before, of 437·5 troy grains. Since the cubit is the half of the second's pendulum, one-sixth of the cube of half the pendulum, is $\frac{1}{48}$th the cube of the whole pendulum; there were therefore 2160 lbs. avoirdupoise English in that cubic content, or 2880 Roman lbs. of 12 ounces each.

Further, as the ancient land measure of India was a rod of ten cubits, so we find the tenth part of the English land measure = 19·8 inches, and this erroneous standard may have arisen out of the arbitrary principle of reckoning the ton equal to eighty quarters each of twenty-eight pounds avoirdupoise, of 7000 grains troy, or the converse; for 28 lbs. × 7000 grains troy, × 80 = 15680000 grains, and $\sqrt[3]{\frac{15680000}{252{\cdot}458}}$ divided by 2, gives the correspondent measure = 19·801 inches English. Whereas a well authenti-

cated memorial of the true original standard is still preserved in the standard wine gallon of Henry the VIIth, which may be thus immediately derived from the primitive universal standard: 39·09785 inches cubed, is equal to 59766·6107, the fourth part of which is the true ancient quarter = 14941·6526 cubic inches: the eighth part thereof, is the true ancient bushel of England, = 1867·7065 cubic inches, and finally, the eighth part of this last measure, the true original content of the ancient wine gallon, = 233·46337 cubic inches; a standard record whereof, was preserved in our national repositories to the days of Henry the VIIth. How nearly this has been found to agree with the measure of a gallon, thus deduced from the primitive standard, may be learnt on reference to the Parliamentary reports, the statute books, and the researches of the Royal Society's Commissioners. The evidence of Mr. Leader, the city guager, and Mr. Flamstead, in the cause brought into the Court of Exchequer in 1700, (Quarterly Review, volume 36, page 142,) is a strong corroborative proof of the above conclusion; "they, and several other artists skilled in guaging," being all agreed, that "a wine gallon ought to contain 231 cubical inches, and no more; that there was such a gallon kept from time out of mind at Guildhall, as a standard of that measure." Computing the cubit from the above, $\frac{1}{2}\sqrt[3]{231 \times 8 \times 8 \times 4}$, = 19·47992 inches English, or about 69 thousandths of an inch less than the primitive cubit. On this same principle we dis-

cover the original of the French septier of the old system, which is one-seventh the cubic pendulum, or 8538·0872 cubic inches; the boisseau, 1067·2609 cubic inches English; the litron, corresponding to the English quart, = 66·7038 cubic inches English. The divisions of this latter national system perfectly explain the origin of the Winchester bushel of Henry the VIIth., and the bushel at Aberdeen of Queen Anne; for these measures of capacity are one-fourth of the French septier, answering to the minot, old French system, being equal to $\frac{1}{4}$ of $\frac{1}{7}$ $(39{\cdot}09785)^3$, or $\frac{59766{\cdot}6107}{28}$ = 2134·5218 cubic inches English: the gallon, or eighth part of which measure, is equal to 266·8152 cubic inches English. On what grounds the Select Committee of the House of Commons determined the exact quantity of the gallon from the bushel measure at the Exchequer, which is specified in the report that followed upon the commissioner's labours, does not appear, but it is said to have been found = 266·1 cubic inches English, and doubtless, after the most careful investigation: from this measure, therefore, the primitive universal cubit would appear to be $= \frac{1}{2} \sqrt[3]{266{\cdot}1 \times 8 \times 4 \times 7}$, = 19·5314 inches English.

A like remarkable illustration of the relation of the weights and measures of remote nations to the primitive system may be instanced from the subsisting measures of capacity of the south of India, which, at no very remote period, were common likewise to the whole of the provinces, north of the

Nerbuddha river. Among a large collection of official documents, which were most liberally transcribed from the public records at Madras, and communicated to me by order of the Right Honorable Sir F. Adam, were three elaborate reports on Weights and Measures; one by Mr. Ellis of the Madras Civil Service, written in 1802, the others drawn up by Major de Havilland of the Engineers, in 1819. These bear ample testimony to the industry of their respective authors, as well as to the benevolent intentions of the Government, to correct abuses, and secure to the people the most equitable and efficient laws, which the combined experience, energy, and talents of its ablest servants could devise. That the suggestions they contained completely failed in the accomplishment of these desirable objects, may well be imagined, from the continuation of the same abuses and misunderstanding to the present day, which then, and now, as heretofore, had called for the interference of the civil authorities.

Mr. Ellis' conversance with the Sunskrit, Tamil, and cognate vernacular languages, would deservedly have entitled his opinions to consideration on any subject connected with the literature and customs of India. Endowed with a sound judgment, he possessed moreover some qualifications, which more particularly recommended his propositions to the favorable notice of the Revenue Board and Government, though ostensibly, they are said to have given them the preference, because they were founded upon the Native system, with which the people were necessarily more familiar than with any which ori-

ginated with foreigners. Major de Havilland's observations were chiefly confined to a specification of the contents of the different standards issued, from time to time, under the authority of Government. His animadversions on Mr. Ellis' plans were probably written without much knowledge of the provincial customs, and certainly with less advertence to the past and present condition of India, or the steps essential to the simplification of this intricate inquiry.

Mr. Ellis, at first, assigned 294,400 cubic inches to the gerise or garce, from trials with a small grain called Oolundoo: he assumes it definitively, to be 300,000 cubic inches; and the murcal, or 400th part of a gerise = 750 cubic inches. Major de Havilland, from numerous experiments, which in principle and fact were altogether illusory, maintained, that the murcal in use was = 828·34 cubic inches, from the mean of five official measures, authorized by the British Government; or, it might be, 834 cubic inches, from the mean of three others, the extremes differing no less than $1\frac{3}{4}$ lbs. avoirdupoise rain water; finally, he proposed a measure of his own contrivance, containing 860·168 cubic inches, because, forsooth, $2\frac{1}{2}$ murcals of this capacity would then exactly correspond with the Winchester bushel, or $\frac{2150{\cdot}42}{2{\cdot}5}$ cubic inches; whereas, such suggestion actually disturbed the true measures, both of the Winchester bushel and Indian murcal: for the last was even then held to be of the exact, or very nearly of the same dimensions assigned or assumed by Mr. Ellis: that is $\frac{8 \times 233{\cdot}46337}{2{\cdot}5}$ or $\frac{1867{\cdot}7065}{2{\cdot}5} = 747{\cdot}08$ cubic inches.

These are Major de Havilland's words : " 6th. In other publications, in which the Madras weights and measures are given, it is stated, that the garce of 400 murcals, weighing 9256½lbs., should contain 300,000 cubical inches, and consequently, the murcal, 750." " 25th. All that I can discover of the parrah, is, that it should hold five murcals : in the Madras Almanac, it is stated that it should be a box two feet square, and 6½ inches deep, but this evidently is erroneous, that measurement only gives 3744 cubic inches ; whereas, five murcals, as I have determined them above, by actual measurement, (at 828·34 cubic inches), give 4141·70, which I shall assume*."

The weight above specified is probably assigned on the

* The unsatisfactory, and for the most part imperfect, replies subsequently returned in 1821-2, by the Revenue officers throughout India, to the Honorable Court of Directors' circular, transmitted by the late Lord Castlereagh at the instance of Dr. Kelly, were still less calculated to remove the difficulties in the way of improvement, or to inform the public as to the actual value of the several local weights and measures in each province. In an inquiry of such immediate and acknowledged importance to all classes, much valuable information might reasonably have been expected from persons so peculiarly qualified to obtain it, and undoubtedly most interested in a thorough acquaintance with its minutest details. Whether from indifference, or yet more culpable negligence, the majority would seem to have considered all attempts at reform equally vain and impolitic : some anticipated incalculable evils, from a reference to standards which the community could neither appreciate nor comprehend ; while a few advised the entire supercession of the weights and measures in use, by those of the mother-country, as the best and only effectual provision against fraud and confusion. Amid this contrariety of opinions, the Government was unable to choose, and matters were left in statû quo.

authority of some ignorant person, because 300·000 cubical inches of rain water weigh 10810·6 lbs. (if it be not the weight of rice or wheat occupying that space ;) and this we are treating of is a measure of capacity, not of weight: it is much more consistent therefore to conclude for the cubical content, rather than the weight. Now the parrah measure being the half of the ghunuhustu, or cubic cubit, $\frac{1}{2}\times\sqrt[3]{3744\times2\times8}$ represents the length of the true primitive cubit, which is 19·5639 inches English : moreover, this parrah measure was truly represented by 16 wine gallons of the standard of Henry the VII. which division of the capacity obtains over all the western coast, subject to the Mharatta rule : the sixteenth part of such parrah or mun measure being termed a pylee, corresponding to the English wine gallon ; the fourth part being termed a seer, corresponding to the English wine quart : the half of this last being termed a tipree, answering to the English wine pint measure. There is therefore every reason to believe, since the measures of capacity of western and eastern India agree, not in principle only, but in their cubic contents, that Mr. Ellis's conclusions were legitimate and probable. The gerise or garce however, derived from the primitive universal pendulum, will be 298833·0535 cubic inches, the parrah 3735·4131 cubic inches : the murcal, 747·08263 cubic inches : all these, as every other dry measure, being striked. The same observations strictly apply to the parrah and murcal of Ceylon, which are in all respects

identically the same as those of the Madras presidency, both in regard to dimensions and use.

To return however to the primitive system itself, it may be very readily imagined that the Britons and ancient Saxons derived their knowledge from the Romans. I have instanced and thoroughly examined all the proofs to this effect, which I could meet with, in a separate publication; but that the Roman measures of capacity were received from the Temple of Jerusalem, may require explanation. Such connection betw een the usages of Rome and Judea undoubtedly did subsist, in respect of their general polity, which has led superficial inquirers to think more highly of the former, than they deserved, and to undervalue the latter, because the people to whom they were transmitted by their forefathers, knew not how to appreciate them. We have seen that the bath being a measure equal to one-sixth of the cubic cubit, held exactly sixty Roman pounds of distilled water, reckoning 252·984 grains troy to the cubic inch: the hin of scripture therefore, which was one-sixth of the bath, was 120 ounces of 437·5 troy grains each, or 10 lbs. Roman measure, and this was also the exact measure, well known to antiquaries as the congius of Vespasian. It is not improbable that this vessel may still be preserved among other curiosities in the Vatican. The cubic content of the congius, which bore a superscription intimating that it held ten Roman pounds of water, was very accurately ascertained by the learned Dr. Greaves, Astronomi-

cal Professor of Oxford in 1639, to be equal to 229·556 Roman cubic unciæ, or 207·597 English cubic inches: the Roman foot taken from the monument of Cossutius, some ancient brass foot rules, and the pavement of the Pantheon, being estimated to contain 967 parts, of which the English contained 1000, and therefore 12·409 Roman solid unciæ, corresponded to 12 English cubic inches. He likewise instituted experiments with millet grain, in English wine and corn measures, of quarts, pints, and fractional parts of a pint; and although he does not specify the cubical contents of the wine and corn measures, we may consider the former at the period of his experiment, (1639,) to have been 231, the latter 268·2 cubic inches, commonly called Winchester measure, from Henry the VII.'s bushel, as these were subsequently confirmed by law, in 1688. The congius contained three quarts, one and one-eighth pints of our wine measure; and three quarts, and about a sixth of a pint of our corn measure; whence by the wine measure it contained 205·734 cubic inches, by the corn measure 206·737 cubic inches, English measure: the Roman amphora of eight such measures was equal to 1836·448 Roman cubic unciæ, or 1660·778 English cubic inches, differing very little from the experiments of Villalpandus, which give 1656·432 English cubic inches for the content of the Roman amphora. This serves equally to show the skill of the operation itself, the correctness of Dr. Greaves' estimate of the length of the Roman foot,

and the connection of the measure of capacity with the primitive system. By Dr. Greaves' estimate, it appears the Roman foot consisted of 967 parts, of which the English contained one thousand, hence the foot measure comes out 11·604 inches English; one and a half foot, or the Roman cubit, (so called) 17·4 inches: Dr. Bernard reckoned the Roman foot to be 970 thousandths of the English foot; hence the Roman cubit, (so called) would be 17·46 inches; now the cube of the first measure, is 5268·02 cubic inches; the cube of the latter 5322·71 cubic inches; the congius therefore did not refer to the cubit, (so called,) either of 17·4 or 17·46 inches, nor to the cube of the Roman foot on one, or other authority, the cube of 11·6 being 1560·9 cubic inches; the cube of 11·64 = 1577·1 cubic inches: it was therefore a foreign measure, or a dry measure raised on a very different principle to the Roman foot or cubit: moreover, since it falls in its proper place in the great patriarchal system, it could only have been received from the Jews, and have represented the *hin*, the sixth part of the *bath*, that is, $\frac{1245 \cdot 0376864}{6} =$ 207·5065 cubic inches. Josephus clears up the difficulty. "After those triumphs were over, Vespasian resolved to build a temple to Peace," "he laid up therein those golden vessels and instruments that were taken out of the Jewish temple as ensigns of his glory; but still he gave order that they should lay up their law and the purple veils of the holy

place in the royal palace itself; and keep them there." Josephus' History of the Jewish War ; Book 7th, chap. 5th, § 7. The celebrated Roman congius of Vespasian, (Archæologia, 1781, vol. 25th, Essay by Henry Norris, Esq.) connects the systems of India, and England, and France, with those of Rome and Judea; and if it were desirable to extend the same scrutiny to other countries, we might, with equal exactitude and ease, establish the conformity of one and all, to their first universal prototype.

To sum up the foregoing particulars; the primitive standard of weight and measure was the mean length of the second's pendulum throughout the globe at the temperature of 39·5° of Fahrenheit's scale, at the level of the ocean, in latitude forty-five degrees, at the zero, or maximum of greatest density of water, which determined the standard of weight: this was styled the measure of the sanctuary, being double the length of the ordinary cubit, and is entitled in Scripture, *Ammah ha Reeshonah;* the former equal to 39·09785 inches English, the latter to 19·54892 inches English. This measure of the sanctuary was divided in two ways, that is, either into 28 or 48 parts: the cubit therefore consisted of 14 or 24 parts. To the former division of the scale, custom has assigned the name of *tussoos* in India, perhaps we may add also *pollices* in the Latin language, and *nails* in the old English system: to the latter division of the scale, mankind appear to have every where agreed upon the same designation of

digits, or fingers; four of which are reckoned to the palm, and twelve to the longer span, and 16 to the foot. Also, 45 to the gyrd or yard, or vara of the Saxons; 42 to the guz of the Saracens, Tatars, and Arabians; 27 to the clothiers' ell, aune, or braccio; and 21 to the half guz or lesser ell. Of the former scale, 28 parts constitute the measures of the first Mohammedan empires and conquests; 24 the guz or artificers' measures of Asia, and the earliest Mohammedan kingdoms; 20, the clothiers' ells of India, Russia, Germany, introduced or derived from the Tatars and Huns. These embrace the principal modern and ancient nations throughout the earth, but it is to be observed, that Egypt, Chaldea, and Rome blended the foregoing system with another part of the patriarchal economy in a singularly confused manner: of this we shall take more particular account in the sequel, merely observing at present, that the measure alluded to, of 21·8745 inches English, in the construction of the molten sea, was the three-thousandth part of the primitive itinerary measure, and in the ratio of 5 to 9, with respect to the forty-millionth part of the earth's meridional circumference of 5 to 2 $\sqrt{20}$, with respect to the mean length of the second's pendulum in latitude 45°, at the temperature of $39\frac{1}{2}$° of Fahrenheit's scale, which was, as we have already stated, the maximum point of the condensation of water. The relation which those linear and itinerary measures bear to the primitive system will be gradually developed in the account of the division

and application of the system itself. It is to be especially noted that the words cubit, foot, span, digit, pace, and so forth, are purely conventional, wherefore in speaking of the Roman of 17·4 inches, it is added for the sake of perspicuity and consistency, the cubit (so called).

The two scales with their subdivisions and respective dimensions, systematically arranged, exhibit the places which the existing lineal measures of different nations occupy, in the primitive system. In a great many places they conform very exactly to their true prototype; in some they differ, as they do also among themselves, in the component parts of each particular national scheme. Of this discrepancy in the first elements we have already given a clear and remarkable instance in the case of the cubit of England, derived from the rod for measuring land; the itinerary measure and weight, in these =19·8 inches and the more correct account still preserved in the standards of capacity, = 19·5314 inches English.

Similar anomalies are readily shown to have prevailed in the old French system; the itinerary and linear measures of which, give 19·3 inches, the septier, minot, &c. the more correct measure of the primitive cubit or half pendulum. Attending with care to the above minutiæ, we can hardly be at a loss to discover the analogy of any lineal measure, submitted for examination, to the true prototype.

Thus, imagine a commissioner sent from England to investigate some intricate questions of landed property, in the interior of Bengal; or which is an infinitely more probable case, suppose a Governor General in Council called upon to pass his sentence on certain plans in contemplation for the adjustment or equalization of the standard rods for the measurement of land, and the apportioning of assessments; suppose in this case, the utmost prudence and wisdom required, not to innovate, yet not to shrink from the performance of a duty, imperative alike as it affected their own consciences, and the interest of the people: suppose in this case, a statement laid before them of three guz measures, sixty of which squared, had been declared in the time of the wise and great Akbar, the legal beegah: with what facility might persons so situated determine without fear of transgressing either observance, according to the following rule?

First, the average dimensions of the slabs of marble in the pavement of the Taj Muhal at Agra, produced by one party, the sides of which represented a guz of Shah Jehan, said to be 42 fingers, = 33·58 inches: this however at variance with the practical existing division of the guz measure, which is found on inspection to be divided into 24 parts; what hesitation could there be, in referring it to the guz measures of Asia, of 24 tussoos, according to the second scale, divided into 28 parts, = 33·5206 inches English?

Second, suppose another party, the tehseeldars of Moradabad, producing certain copper wires as counterparts of the actual measures from which their beegahs were formed = 33·50 inches on the average; another party delivering in the Ilahee guz of Akbar, ratified by Mr. Duncan, at Benares = 33·6; could there exist a moment's doubt that they represented the above measure of 24 tussoos? that the average measurement of 76 men's fingers' breadths = 31·55 inches; Mr. Newnham's (from the average size of 14 charyaree rupees), giving a measure = 29·20 inches: the testimony of inhabitants at Furukhabad = 31·50 inches: the $\frac{1}{2}$ sum of the diameters of 40 munsooree pice = 32·02; that one and all these are altogether fanciful, and untrue? Yet such questions are far from being unimportant, or of rare occurrence, and they secretly betray the skill, attention, and fidelity with which such inquisitions are made on the one hand, the apathy or mistrust with which they are viewed by the people, as they themselves consider such inquisitions of little, or of the greatest, consequence to their own immediate interests.

The foregoing I have had an opportunity of examining, from the accounts appended by Mr. James Prinsep*, Secretary to the Asiatic Society of Cal-

* This is the only scientific periodical in India, and it deserves a far more extensive circulation from the very able manner in which it is conducted by its present editor: to the learned in Europe it may be expected to prove of great utility in matters connected with the arts, sciences and literature of Asia.

cutta, to the Asiatic Journal, for June, page 89. Had the same industry been evinced throughout India, as in the case of the inquiries of Mr. Duncan, and Major Hodgson, we should not have to complain of the irreconcileable discrepancies which embarassed the measures of the Revenue Boards and Government to no purpose.

FIRST SCALE; divided into forty-eight parts:

Primitive standard, or unit, 48 parts or digits, = 39·09785 inches English, the mean length of the second's pendulum in latitude 45°; at the level of the ocean, at the temperature of 39½° of Fahrenheit's scale.

Parts.		Inches English.	Correspondent or relative measures of other nations.
Unit,	48	39·09785	*A* Spanish vara, Persian arish, Arabian and Saracen ba,a.
	47	38·2833	
	46	37·4687	*B* The English or Saxon gyrd, or yard, properly speaking the Saxon ell of 45 digits, miscalled inches, 45 digits: 24 digits :: 36 inches: 19·2 inches, the length of the cubit thence resulting of 24 digits, which very nearly agrees with the ancient Norman, or French,=19·3 inches.
	*45	36·6542	
	44	35·8397	
	43	35·0252	
The Kiskoo, or Arutnee of India,	†42	34·2106	*C* Mogul and Tatar measures; Rome, braccio di Mercanti; the varas of Spain, Portugal, and dependencies.
	41	33·3961	
	40	32·5815	
	39	31·7679	
	38	30·9524	
	37	30·1369	
Three quarters,	*36	29·3224	
	†35	28·5078	
	34	27·9933	
	33	26·8787	
	32	26·0652	
	31	25·2507	
	30	24·4362	

Parts.	Inches English.	Correspondent or relative measures of other nations.
	29 23·6213	
	†28 22·8068	
$\frac{1}{72}$; or ell,	*27 21·9918	*D* The braccio of Italy, Switzerland; the rasi of Sardinia; the ells of Cassel, Coblentz, Dresden, Cracow, Leipsic, Riga, Heidelberg; (the fourth of the Italian canna).
	26 21·1781	
	25 20·3625	
One-half, or cubit,	24 19·54892	*E* The cubit universally. Measures of Italy, Switzerland, France, (old system,) Lisbon, Russia, Morocco.
	23 18·7349	
	22 17·9198	
The rutnee of India,	†21 17·1053	*F* The measures, miscalled cubits, of Sweden, Germany, Russia, Austria.
	20 16·2907	
	19 15·4762	
	*18 14·6612	
	17 13·8467	
One-third, or foot,	16 13·0326	*G* The Chinese, Burmese, Siamese, Japanese, and Asiatic Islanders, foot measure.
	15 12·2181	
	†14 11·4034	*H* The foot measure of Genoa.
	13 10·5890	
One quarter, or span,	12 9·7745	*I* The palmi of Genoa, and the states of the north of Italy.
	11 8·9599	
	10 8·1453	
	*9 7·3306	
	8 6·5163	
	†7 5·7017	
	6 4·8872	
	5 4·0725	
$\frac{1}{72}$th, or palm,	4 3·2581	*K*
	3 2·4436	
	2 1·6291	
$\frac{1}{288}$th, or Digit,	1 0·8145	*L*

Note.—The letters refer to the details hereafter given, and the reasons for assigning each measure to those parts of the scale.

The asterisks (*) denote the connection or grouping of different national systems, by the division of the gyrd or yard, and ell, of 45 parts, or digits, into five portions of nine digits each.

The mark (†) denotes the connection or relationship of different national systems, by the division of the guz, or vara, or ell, or braccio, of 42 parts or digits, into six portions of seven digits each. This last had its origin in the second division of the scale into 28

parts, being three times 14, the number of divisions in the cubit, according to the second scale.

SECOND SCALE, *Amma Benoni.* The Architect's rule: divided into 28 parts.

Primitive standard or unit, *Ammah ha Reesho-nah*, the sanctuary standard = 28 parts = 39·09785 inches English, the mean length of the second's pendulum, in latitude 45°, at the level of the sea, in the temperature of 39½° Fahrenheit.

Parts or Tussoos.		Inches English.	Correspondent or relative measures of other nations.
Unit,	28	39·09785	*A* The Spanish vara; the Persian arish, and Saracen, or Arabian ba,a.
	27	37·7014	
	26	36·3050	
	25	34·9088	
	*24	33·5125	*M* Guz measures of Asia; varas of Spain, Portugal, the ancient Portuguese and Spanish dependencies of Majorca, the Canary Islands, Gibraltar, and the Colonies of those crowns.
	23	32·1161	
	22	30·7198	
¾ths, unit,=	21	29·3234	
	*20	27·9271	*N* The guz of Malabar, of the ancient Saxons, still in use in Wales; the Russian arsheen; the ells of Germany, Holland, and the Low Countries.
	19	26·5307	
	18	25·1343	
	17	23·7380	
	*16	22·3416	
	15	20·9453	
The half, or cubit,	14	19·54893	*E* The cubit universally.
	13	18·1525	
	*12	16·7562	
	11	15·3599	
	10	13·9645	
	9	12·5672	
	*8	11·1712	
¼th, unit,	7	9·7744	*O*
	6	8·3781	
	5	6·9820	
	*4	5·5856	
	3	4·1890	
	2	2·7928	
	1	1·3964	*P*

NOTE.—The asterisks (*) thus prefixed, shew the connection of the systems of different nations with the guz measures of 24 parts, which are subdivided into six portions of four each. The letters as in the preceding.

Secondly: The basis of the dry or liquid measure was the cube of the mean second's pendulum or primitive standard, divided exactly in the same manner as the lineal measure: that is, by two distinct scales,—into twenty-eight parts, for the convenience of taking the seventh, the fourteenth, the twenty-first, or twenty-eighth portion;—and into forty-eight parts, more convenient for the halving and duodecimal division. These scales and their respective divisions, with their correspondent contents in English cubic inches, are as under.

The cube of the pendulum, the unit or basis of measures of capacity, according to the primitive system was = 59766·6107 cubic inches English measure.

The half of this unit 29883·3053 = $\frac{1}{16}$ the gerise or garce of Madras and Ceylon.

The quarter of this unit = 14941·6526. The true ancient English quarter.

The eight of this unit = 7470·8263 Indian ghunuhustu, the cube of the cubit.

The sixteenth of this unit = 3735·4131 Indian mun or pharra.

The thirty-second of this unit = 1867·7065 English bushel of Henry VIIth.

The forty-eighth of this unit = 1245·0377 Jewish bath or Epha of Scripture.

The coomb of England, and the *coombha* of India; the karrick of England, and the *karikia* of India; the *baha* of India, and the wey of England, occupy like places in this scale.

The second scale, or cube of the primitive standard, the mean length of the second's pendulum divided into twenty-eight parts. Cube of the primitive measure, or unit of measure of capacity for liquids and dry substances, 59766·6107 cubic inches.

	Cubic inches.
The seventh part thereof, the French septier, ...	8538·0872
The fourteenth of the unit,...	4269·0436
The twenty-first of the unit, ...	2846·0291
The twenty-eighth of the unit, equivalent to	2134·5218

or the English and Scotch bushel, (the bushel of Queen Anne.)

The czetwer of Russia, and the tonnen of Prussia, are the fifth of the cubic pendulum, = 11953.3221 cubic inches, the années of the south of France, the *anas* of India; the razieres of the lower Rhine, and the *ras* of India, are derived from this scale.

Thirdly: the basis of the primitive system of weights of whatever kinds was in all respects exactly the same as the above in principle, and represented by the weight of such portions of rain or distilled water, each cubic inch supposed to weigh 252·984 grains troy, at the temperature of 39·5° of Fahrenheit, at

the level of the ocean, in the latitude of 45°. It was divided also precisely in the same way, i. e. into forty-eight and twenty-eight parts.

FIRST SCALE; unit of weight the cube of the mean length of the second's pendulum, 59766·61075 cubic inches × 252·984 grains troy, = 15,120,000 grains troy, divided into 48 parts.

	Grains Troy.	lbs. av.		lbs. Rom.	Cubic inches.	
Unit of weight,	15,120,000	2160	each lb. avoirdupoise of 16 ounces, each ounce 437·5 grains Troy.	2880	59766·6107	
One-half of unit,	7,560,000	1080		1440	29883·3053	
Quarter of unit,	3,780,000	540		720	14941·6526	
Eighth of unit,	1,890,000	270		360	7470·8263	
Sixteenth of do.	945,000	135		180	3735·4131	
Thirty-2nd of do.	472,500	67½		90	1867·7065	
Forty-8th of do.	315,000	45		60	1245·0377	the Bat.
1-6th of 1-48th of the unit.	52,500	7½		10	207·5065	the Hin.
1-24th of 1-48th of unit, or maneh of 60 shekels,	13,125	1·875		2½ each Roman lb. of 12 ounces, each ounce of 437·5 grains Troy.	51·8766	the Kab.

Correspondent weights of other nations.

The forty-fifth part of the forty-eighth of the unit of weight, = 7000 grains troy; one pound avoirdupoise represented by 27·6675 cubic inches of water. The sixteenth part of the forty-eighth of the unit of weight, = 5250 grains troy; one pound of Italy, and Sweden. The two thousandth part of the unit of weight,=7560 grains troy; the pound of Scotland, France, Switzerland, Holland, and North of Italy.

The nine hundred and sixtieth part of the forty-eighth of the unit of weight, the English avoirdupoise or ancient Roman ounce, = 437·5 grains troy.

SECOND SCALE; unit of weight divided into 28 parts.

	Grains Troy.				Cubic inches.
Unit of weight,	15,120,000	2100	lbs. of 15 oz. each of 7200 gr. tr. each oz. 480 gr. troy.	2800	59766·6107
Seventh of unit,	2,160,000	300		400	8538·0872
Fourteenth of ditto,	1,080,000	150		200	4269·0436
Twenty-first of ditto,	720,000	100		133⅓ lbs. of 11¼ oz. each of 5400 gr. tr.	2846·0291
Twenty-eighth of ditto,	540,000	75		100	2134·5218

Correspondent weights of other nations.

The hundredth of the twenty-eighth of the unit of weight, the ancient Saxon and Norman pound, = 5400 grains troy, = 5760 grains troy, minus three-quarters of an ounce. The seventy-fifth of the twenty-eighth of the unit of weight, the German pound, = 7200 grains troy; also the old commercial, or merchant's pound of fifteen ounces of England, = 7200 grains troy, which as well as the former of 5400, were abolished by statute in the 18th year of the reign of Henry VIII. A. D. 1527.

The ounce or the fifteenth part of the merchant's pound, = 480 grains. The existing English troy pound of 5760, derived from the merchant's ounce, or pound, being as 12 to 15, with respect to the latter, or 12×480 = 5760 grains troy.

The foregoing tables perfectly explain the origin of all the weights and measures of capacity, throughout the world, and set at rest many questions which have been proposed by the learned in Europe, regarding the origin of the troy and avoirdupoise pound. For as the septier and its multiples and aliquot parts came into England when the intercourse with France was greater, and when in fact a part of France was annexed to the crown of England, the correspondent weight, formed on the like principle and division of the scale, was introduced likewise: so that we had two systems of dry measures, and two of weights; the former, and much more ancient,

being the Roman of 12 ounces to the pound, each ounce 437½ grains troy, each pound of 5250 grains; or of 16 ounces to the pound, each ounce of 437½ grains, each pound of 7000 grains. So likewise in regard to the measures of capacity, we had the bushel and quarter of the first scale which were derived from, or transmitted down to the Britons and Saxons by their Roman conquerors, and the septier, minot, boisseau, and litron, introduced most probably in the time of Henry V., or it may be, some few years earlier.

It may be as well to shew in this place the origin of the ton, English weight, which is thus explained by Minshen, after Fleta, lib. 2, cap. 12th. "All our English measures are compounded of the penny sterling, which weigheth 32 cornes of wheat of the middle sort, and that two (2) of those pence make an ounce, and twelve ounces a pound in weight, or three score shillings in number, and that eight lbs. of wheat maketh a jalon, or gallon, as we now call it, and eight gallons a bushell, and eight bushells a common quarter; also that fifteen ounces of the quantity aforesaid doe make a merchant's pound, and that twelve such pounds and an halfe doe make a stone, and that fourteene stone doe make a waight, and that two waight, or eight and twentie stone, doe make a sacke of wooll, (which ought to weigh a quarter of wheat) and that twelve sacks make a last, and that a weight and a sarplar seemeth to be all one, but

that the sarplar is the case, and the waight respecteth the quantitie of the wooll itselfe, and that a load and a sarplar is all one." (Minshen, 11420, in Verbo Serplathe.)

The above passage is remarkable for its differing so materially in the account of the value or weight, of the old English ounce.

The ordinances of 51st Henry III. A. D. 1266, and 31st Edward I., merely repeat those of William the Conqueror, that the "English penny called a sterling, round and without clipping, shall weigh thirty-two wheat corns in the midst of the ear, and twenty pence to make an ounce, and twelve ounces one pound, and eight pounds do make a gallon of wine, and eight gallons of wine do make a London bushel, which is the eighth part of a quarter."

Now the basis of the whole fabric of the system of English weights, as Mr. Adams, Secretary of the United States, in his Report to the President, has correctly observed, was the ancient penny sterling, but not the silver: it was in short nothing more or less than the Jewish shekel, or standard of weight delivered down through the Romans. Two of these shekels by weight made the avoirdupoise or Roman ounce of 437·5 troy grains, and for this reason we are to consider the pounds of 5250 grains, and 7000 grains, also the ounce of 437·5 grains, to have been long in use before the pounds of 7200, and 5400 grains of the second scale; which were brought in by the Norman barons.

The word sterling refers to some ancient standard, as the Saxon term *steore* implies ; from whence it is derived rather than easterling, the name given to the Hanse Town and German merchant's fraternity, specified in the statutes of the 22nd year of Henry VIII. (being the principal or standing measure of the king, to the scantling whereof, all the measures thorow the land are, or ought to be framed, by the clerke of the market, Aulneger or other officer according to their functions). For it was established by the statute of Magna Charta, Anno 6, Henrie III. cap. 9th, that there should be but one skantlin of weights or measures thorow the whole Realme, which is sithence confirmed by Edward III. Anno 14, cap. 11, and many other statutes, as also that all should be fitted to the standard sealed with the king's seale." Setting aside therefore the many fanciful derivations of the word proposed by Skene, Linwood, Rapin, &c. we may be satisfied of its high antiquity from the statute of the 25th of Edward III. and although it is considered by Camden to allude to the Flemish workmen, introduced into Great Britain, in the reign of king John, who going usually by the name of Easterling Merchants, perpetuated their skill in minting, by the application of their proper designation to the coin of England ; it is far more probable that it came down from the time of Edgar, significant of some ancient rule, which was lost sight of, or confounded, with the appellation of the Flemish merchants. Through the Saxon word

steore, the Persian and Arabic *istar*, and the Greek *stateer*, (see Golius and Scapula sub verbis,) synonimous with the European shilling, the continental skilling; the Roman sicilicus, the oriental mishkol, and the patriarchal or Jewish shekel, we may trace it up to its true root, and find how exactly it was raised after the same principle: for in this 32 perootahs or garin (grains) = 1 maa or gerah; and 20 gerahs, = one shekel: so the English table was made to run thus, 32 grains make a pennyweight, (obolus;) 20 pennyweights one ounce; 2 shekels of commerce, one ounce.

It is probable the English ton weight was formed by the confusion of the Jewish stone of 14 lbs. two of which were reckoned equal to a quarter of a hundred pounds, and the commercial pound of the second scale of 7200 grains: for as we have shewn above, 640 grains were reckoned to the shekel: now $11\frac{1}{4} \times 640 = 7200$, to which adding 640 grains, we get 7840 grains, and this multiplied by 100, and divided by 28, gives 7000 grains for the heavy pound of the first scale: how liable persons are to fall into such errors might be better understood by the perusal of the statutes on this subject, within the last two hundred years in England.

The primitive money weight was the shekel of the sanctuary, called *khodesh shekel*; in contradistinction to the common or civil shekel, *kol shekel*; in the former case the shekel was double the latter, or one ounce in weight.

	Troy grains.
32 perootahs = 1 maa or gerah ... =	21·875
320 perootahs = 10 do. = 1 beekah =	218·75
20 gerahs = 1 shekel = 2 beekahs =	437·5
60 shekels = 1 maneh ..... =	26 250
50 maneh = 1 talent or keekur, =	1312500.

But the use of this was restricted to the temple. The *kol shekel* was half an ounce troy weight.

	Troy grains.
32 perootahs = 1 maa or gerah,.....	10·9375
10 gerah or oboli (οβολοι) one drachma,...	109·375
20 gerahs = one shekel = ...	218·75
60 shekels = one maneh = ...	131 25
100 maneh = one talent of the sanctuary,	1312500.

This talent of the sanctuary was of twelve thousand drachmæ, or ten thousand Phillippics, or thick drachmæ of Corinth, each = 131¼ grains troy; but contained of its own, but 6000 beekahs.

The fourth part of the shekel, or the half of the drachma, was the deenar, = 54·6875 troy grains. The Phillippic, was the same coin as that specified in the 2nd of Ezra, called Darics, which weighed 12 gerahs each.

The kol shekel is first noticed in Scripture as current in the days of Abraham, 2053 B. C. being regularly stamped and coined, as we are led to infer from the Hebrew words, *Arba meoth shekel, kesef ober lassokher*, "four hundred shekels of silver, current money with the merchant." Genesis, chap.

xxiii. verse 16th; that is, 400×218·75 troy grains. Here the money is spoken of and specially numbered as a coin; the circumstance of its being weighed out, every one who has visited Asia, well knows is a practice of frequent occurrence even at this present day, especially in the reckoning of large sums, which otherwise must not only be tedious to a degree, but attended with great liabilities to error or fraud: in our public treasuries in India, it is always weighed out, or very seldom counted. Now the first money coined in Greece, the supposed centre of science and art, was not until 1100 years after, i. e. B. C. 895, when Megacles was Archon: for according to the Parian chronicle, translated by Hewlett, from Dr. Chandler's edition of that curious and valuable record of antiquity; "During the reign of Megacles," it is said, "Phoidon the Argive was proscribed, and made measures and weights, and coined silver money in Ægina." The shekel of the sanctuary, *shekel hakkodesh (kodesh* "holy"), was of twenty gerahs: Exodus, chapter xxx. verses 13 and 24: Exodus, chapter xxxviii. verses 24, 25, 26: Leviticus, chapter v. verse 15; chapter xvii. verses 3, 25; Numbers, chapter iii. verses 47, 50; chapter vii. verses 13, 19, 25, 31, 37; chapter xviii. verse 16. This shekel in all these instances is most expressly distinguished by the affix *of the sanctuary*, "from that current with the merchant," Genesis, chapter xxiii. verse 15; or shekels "after the king's weight," 2 Samuel, chapter xiv. verse 26; wher-

ever the shekel pertaining to the temple, or dedicated to the service of the Lord is spoken of, it is with this adjunct, but no such distinction is elsewhere applied. It is a fair conclusion that it was as perfect in every respect, as the coins of the present day; that in regard to form, impress, the due admixture of alloy necessary to its durability, it was calculated as a ready and just criterion of weight, no less than of a true and equitable standard of commercial value.

That the shekel of the sanctuary differed most essentially from the civil or commercial shekel, appears from a critical examination of certain passages of scripture: compare, for instance, the passage in the 17th verse, 10th chapter, 1st book of Kings, with the 16th verse of the 9th chapter of the 2nd book of Chronicles. From these we collect that three pounds or three hundred *(pieces)* of gold were employed in making each shield; it is not said that they were *shekels* in the original, but *duhub*, gold. We may believe with great reason, that these pieces of gold were of the number presented to King Solomon, either by the Queen of Sheba, or the kings of Arabia, and governors of the country, wherefore being strictly an honorary present to a great earthly monarch, they were not distinguished in any more precise way. The narrative simply states, that three manehes of gold went to a shield, each such maneh consisting of 100 pieces of gold, that is, $\frac{13125}{100} = 131{\cdot}25$ troy grs.

each. The practice of calling coins by the name of the metal, obtains very generally every where; so in India, *hoon*, which signifies gold in Halla Canarese; *roopuya*, silver, or a rupee; the Grecian καλκος and χρυσος, the Roman *aureus;* &c. This coin therefore forms a part of the second scale, being the same as the Philippic of 12 gerahs, exactly the ten thousandth part of the talent of the sanctuary, without supposing which to be raised from the shekel of the sanctuary of 437·5 troy grains, there would be a still greater difficulty in determining what coin to refer it to. Prideaux, and many learned commentators have argued that the Alexandrian drachma was double the Attic: whether this opinion be well founded, must be established from other than scripture data, for the Alexandrian Jews who made the Septuagint translation, would scarcely have thought of adding the expletive το αγίον, "the separated," in their translation of the 30th chapter of Exodus, verse 13th and 24th; had it been identically the same as the shekel of the sanctuary; they would not have rendered *shekel hakkodesh* by διδραχμα το αγίον. In this, as in all other disputed passages, Scripture itself, is its own best and only interpreter. In the 17th chapter of St. Matthew's gospel, verse 24 to 27, the margins of our bibles preserve the true rendering of the original Greek, δίδραχμα, translated "tribute;" and στατηρ, translated "a piece of money." By a close adherence to the original Greek, and perhaps also a better term for the word

κηνσον, (capitation tax,) the nervous simplicity of the passage would be restored, and the meaning conveyed to every understanding, and thus, placed appositely with the septuagint version of the injunction in Exodus, prove, *primâ facie*, the intent of the Alexandrian Jews, to convey the full and strict meaning of the Hebrew. The tribute money to the Romans, was a tax levied independent of this didrachma, throughout all the conquered provinces, annexed, or subjected to the empire, and it is particularly noticed in two places of scripture; Matthew, chapter xxii. verse 17th, 19th; and Mark, chapter xii. verse 14th.

This was to all intents and purposes a tribute or acknowledgement of submission or bondage to a foreign yoke, κηνσον, assessed, or capitation tax, of a denarius, levied simply with reference to numbers, and not to the age of discretion, to which the persons enumerated had arrived, when they virtually acknowledged the *legal* ransom paid for their souls, and were then considered to be spiritually emancipated by the law. Josephus illustrates the nature and amount of this payment, (Jewish war, book 7th, chapter 6th, section 6th.) "Titus Cæsar," (A. D. 71,) "also levied a tribute upon the Jews, wheresoever they were, and enjoined every one of them to bring two drachmæ every year, into the capital, as they used to pay the same to the temple at Jerusalem." From a review of all these particulars, there can remain little doubt that the preceding statements of the

shekel of the sanctuary, and shekel current with the merchant, or after the king's weight, are substantially correct.

It may be judged by far the most curious to trace the same system, by examination of the Chinese, and Hindoo, and Arabian coins and weights: in these countries, the *mace*, the *massa*, and the *maa*, point out to the exact element corresponding to the primitive system. Take for instance the Hindoo; the rule or definition in the shasturs, is twelve massas to the tola; 28 tolas to the seer, or nearest weight corresponding to the pound: now; $\frac{5250}{28\times12}$, or $\frac{437{\cdot}5}{28}$, $= 15{\cdot}625$ grains, which in fact is the exact weight of the massa deduced from the most ancient coins extant. Twelve of these constitute the weight of the tolah $= 187{\cdot}5$ troy grains. Again, the true ancient *hoon*, or pagoda, is three and a half massas weight, $= 54{\cdot}6875$ troy grains; equal to half the drachma, of $109{\cdot}375$ grains. The gold *punum*, or fanam, is the tenth part of the ancient hoon, or pagoda, $= 5{\cdot}46875$ grains troy.

The Mahommedans, adhering to the true standard pound of 12 ounces, or 5250 grains, have coined a hundred pieces of gold from the like quantity, whence the later hoons are found equal to $52\frac{1}{2}$ grains; the later fanams $5\frac{1}{4}$ grains. I examined a large collection of coins and weights with much care, and found the agreement as near as could have been expected from the several mints. Other coins have

likewise been assayed and weighed by Mr. B. Noton, Assay Master at Bombay: Mr. H. H. Wilson, and Mr. Prinsep, Assay Masters at Calcutta: and Mr. Bannister, Assay Master at Madras: lastly by Mr. Bingley, and Dr. Kelly, in England, from specimens, or counterparts sent home in 1822.

To these may be added the names of Dr. Buchanan, and Mr. Heynes, who reported faithfully as far as their opportunities allowed, on those of the Madras territories.

From various sources the weight of the Calcutta Sicca Rupee is stated to be $12\frac{1}{2}$ massas, the weight 191·916, the massa therefore is $= \frac{191{\cdot}916}{12{\cdot}5} = 15{\cdot}3532$ troy grains.

The tola of Malwa, specified by Captain Dangerfield, to Sir John Malcolm, is 190 grains, and said to be of 12 massas; the massa therefore $= \frac{190}{12} = 15{\cdot}8333$ grains.

The Kota pice in Malwa, = 276·6 troy grains of 18 massas, hence the massa = 15·3666 troy grains.

The Surat massa examined by myself, = 15·5435 troy grains. The same examined by Mr. Bingley, and Dr. Kelly, from the counterparts sent to England for examination in 1822 = 15·60 troy grains.

The new Bombay gold-mohur, and silver rupee each of 180 grains, and $11\frac{1}{2}$ massa, hence the massa = 15·652 grains troy.

The Madras coinage the same, the massa = 15·652 troy grains.

The Calcutta gold-mohur, weighing 204·71 grains, divided by 13·28152, the number of massas contained therein, gives for the massa, 15·413 grains troy.

From a very large collection of coins and weights examined by myself, on the western coast of India, and the Mharatta fœderal states, the general average was 15·6078 grains troy.

From the copper coin, named at Madras the *Dub*, (Heynes' Statistical Reports,) corresponding to the pice of Kota in Malwa, of 18 massas = 275 grains troy, which gives, $\frac{275}{18}$ = 15·277 grs. for the massa.

From the heavy weights of the Mharatta states submitted to my examination, of 24, 26, 28, and 72 tolas, the average massa was 15·573 grains troy.

The average massa of the gross weights of the late Peshwa's dominions, of 72 tolas, was 15·972 grains troy; the tola being 191·66 grains, at Ahmudnuggur, Sungumneer, Unkola, Kotool, Rajoor, Kurmulla, Kurda, Indapoor, Jooneer, Poona, and Dhoolia.

The Jaulna masha = 15·373 grains; the Ahmudnuggur massa, = 15·7; the Malwa massa, = 15·833; the Poona massa, 15·97: (according to Kelly's Cambist.)

The average of several gold and silver jilalees of Akbar's reign, found in good preservation, gives 15·5 grains for the masha: according to Mr. James Prinsep, Sec. As. Soc. Calcutta.

A gold jilalee of Lahore, rather worn, 186·6 grains, according to Prinsep, which he takes to be 12½

massas, but is more probably the tola of 12, each massa of 15·55 grains troy.

The ancient hoons of the Mysoor and Anagoondee kings have nearly disappeared, the punums are more common: the modern hoons average 52·5 grains.

These instances suffice to prove the correspondence of the Hindoo to the universal system. The names are not entirely lost, as I found in the *Wydhyu-grunth*, a Hindoo treatise on medicine, (or the Hindoo medico-incantation art,) which as usual is prefaced with tables of weights and measures, the tunku, (better known by its corrupted names, *tank*, *tuk*, or tack,) is there called dhurum, khan, kol, and nishk, by which last term the quantity is more familiar to the Brahmins, and frequently used in their shasturs; 2 tunku, = 1 kshoodrum, drukshum, or uwut; one tunku, = 4 massa; and 3 tunku, = 12 massas, = one tola: 6 massas, = one gudyana, a weight well known in Cutch, and Sinde, and the territories bordering on the mouths of the Indus; here dhurum and drukshum are evidently clumsy corruptions of the Greek drachma, or the Arabian dirhem; the *massa*, nishk, and kol, are words of Hebrew or Arabic original; the disjointing and transposition of the syllables, and the mistake of the letter *n*, for *m*, gives nishk and kol, mishkol, (the shekel weight,) Ezekiel, chapter iv. verse 10th.

It may be proper to notice that the discrepancies of existing weights, measures, and coins have been

supposed much greater than they really are, from inattention to the division or fundamental elements: a guz of 42 digits, or a guz of 27 digits, would probably give the measure of 24 digits, conformable to the truth: a guz of 24 tussoos, of 20 tussoos, or of 18 tussoos, would give the cubit of 14 tussoos, pretty nearly alike, however widely those lineal measures might differ in respect of their absolute lengths: the rupee of 12, 11½, 11, or 10½ massas might, by ignorant persons, be called a tola, yet the massa would be very nearly alike in all: and so of the measures of capacity and heavy weights, there are correspondent parts or elements which prove incontestibly a reference to some one common principle, which had been lost sight of, in the lapse of ages; and that principle, the very one which we have now been investigating. From a review of the subject it is obvious that nothing has so obstinately resisted deterioration as this, nor does any branch of legislation so forcibly declare the futility of innovations dictated by private judgment, or the peculiar interests of any one nation in particular: a law of this nature, to be efficient and permanent, must be universally operative and acceptable.

We may now consider the nature of the other measure, which entered into the construction of the molten sea, equal to twenty-one inches, eight hundred, and seventy-five thousandths English, nearly; which according to received opinion, is of Egyptian, or some may say, of Chaldean origin; but the infinitely

greater probability is, that it was first communicated to the Egyptians by the patriarch Joseph, because it forms an essential part of the patriarchal scheme; the honorary title, moreover, by which Joseph was distinguished by Pharaoh, implies also a revelation of some hitherto unheard-of methods, calculated to ensure the most perfect and just distribution of the lands, produce, and revenues of Egypt, and to perpetuate the same, as well to the full term of that prince's days, as to all future ages. Genesis, chapter xli. verse 45.

Now the collection and amount of the revenues of Egypt, which is exclusively irrigated by the annual overflowing of the Nile, is determined by the height of the inundations; to which intent, a standard measure called *mikyas*, or the nilometer, was erected by Joseph, somewhat more than commensurate with the full quantity necessary to the fertilization of all that tract bounded by Syene and Elephantina. This for its peculiar richness of soil, for the certainty and abundance of its crops, was well called "the granary of the world." The *mikyas*, or nilometer, was divided into twenty parts: Bruce measured this monumental standard with every practicable precaution, and found it 36½ feet high, which gives for each twentieth part, or measure, 21·9 inches English, more or less: these measures are again subdivided, each into 24 others, with the exception of the lower two, which are plain.

The nature of a distribution whether of land or revenue, dependent on such phenomenon, precluding, as it necessarily must, every ordinary method of computation or definition, called forth the ingenious device in question, which served to maintain a permanent rule of equity—accessible, simple, intelligible, to all, and as we may infer from its acceptance and perpetuation, superior in every respect, to any that had been resorted to, or could be expected. Whence, having been introduced and used time immemorially in Egypt, it obtained the name of the Egyptian peek, πηχυς, arbitrarily rendered cubit, by Europeans, as conveying the idea of some sort of relationship to the natural *cubitus*, or fore-arm, because forsooth the Hebrew word *ammah* admitted of such double interpretation, and this last mentioned was one of them.

It is plain, from inspection of the divisions of the primitive standard of 39·09785 inches, into 48 or 28 parts, that the measure of 21·8746 inches, does not fall into any even place of digits in either scale. Indeed, the design or use of it was exclusively directed to the just distribution of lands and produce, as far as we can judge from what precedes. Its more full and appropriate intent, however, was the simple expression of measure connected with the earth's dimensions, that is, with the measure of the earth's circumference, or the measure of a degree, and the superficial extent, whether of the whole globe, a single degree on its surface, or any portion.

To this end, a lineal quantity was selected, equal to the two hundred thousandth part of a degree on the meridian, in the latitude of 45° ; or the seventy two millionth part of the earth's meridional circumference = 21·874675179 inches English. Thus $\frac{21{\cdot}874675179 \times 200{,}000}{12 \times 6}$, = 60762·986 fathoms, represents the mean length of a degree on the meridian, or the length of one degree, in latitude 45°.

The patriarchal or Jewish itinerary measure, was the 24,000th part of the earth's meridional circumference, each such itinerary measure, or bereh, as it was called, that is, a mile, or *meel*, being equal to 3000 measures; the measure itself, therefore, the 72,000,000th part of the earth's meridional circumference, or $\frac{131248051{\cdot}0764841044}{72{,}000{,}000}$ feet, = 21·874675-179 inches. That this was the identical primitive mile, is discernible in the very imperfect allusions to the systems handed down to us by the Greeks, Egyptians, Chaldeans, and Romans. The tables of the latter for instance, furnish us with a clue to the present argument: for the *mille passus*, or mile, was an itinerary measure of 1000 paces, 5000 feet, or 80,000 digits, there being 16 digits to the foot; therefore $\frac{16 \times 5 \times 1000}{3000}$, or $\frac{80{,}000}{3000}$, = 26·666+ digits, the length of the fundamental measure of the patriarchal, or Jewish bereh.

Now the forty millionth part of the earth's meridional circumference is to this fundamental measure precisely as 48 to 26·666 digits; or, as 9 to 5, or 72 to 40: not to the digits of the Roman cubit, but to the digits, or 48th parts of the forty millionth of the earth's meridional circumference: it has been insisted on, as an indispensible precaution to remember that this essay supposes the word digit, purely conventional, and so also, here.

In the absence therefore of more direct evidence, the adaptation of the detached elements, the tables and nomenclature of all other nations, to one great universal consistent system, deducible as from the passages of scripture now under investigation, we are best to adjudge to whom to ascribe the prior and most perfect acquaintance with its real scientific character.

According to Professor Airy's Essay on the Figure of the Earth in the Encyclopædia Metropolitana, quoted by Sir J. Herschel, Astronomy, chapter iii. p. 117, the curve of the earth's meridional circumference is supposed to be an ellipse, and the lengths of the axes, " which best agree on the whole, with the entire series of meridional arcs, which have been satisfactorily measured, are as follows,

" Greater or equatorial diameter = 41,847,426 feet = 7925·648 miles.

" Lesser or polar diameter = 41,707,620 feet = 7899·170 miles.

"Difference of diameters, or polar compression, 139,806 feet = 26·478 miles.

"The proportion of the diameters, is very nearly that of 298 : 299, and their difference $\frac{1}{299}$ of the greater, or a very little greater than $\frac{1}{300}$ *."

Now putting E for the equatorial diameter, and P for the polar: also the ratio of the circumference to the diameter of a circle, as 3·1415926535897932384 to 1, or as c to 1, then $\frac{E+P}{4} \times c + \frac{c}{2}\sqrt{\frac{E^2+P^2}{2}}$, will express the circumference = 131248051·07648410-440446 feet: the seventy-two millionth of which, expressed in inches, is the measure used in the calculation of the content of the molten sea, from which the primitive lineal standard, or mean length of the second's pendulum at the level of the ocean in latitude 45°, at temperature of $39\frac{1}{2}°$. (in vacuo) was derived, and with which therefore it is necessarily combined, as forming an integral part of one system.

From a comparison of the Lapland, British, French, and Indian surveys, the ellipticity, or ratio of the polar to the equatorial axis of the earth, 304

* It is not the least remarkable proof that the figure and dimensions of the earth given by Professor Airy are correct to an extraordinary degree of exactness, that the earth's surface computed by the most precise formula, and divided by the mean superficial degree, gives 3692162451·41 fathoms, the square root of which is the length of the degree on the meridian in latitude 45°, and exactly the same as 200,000 Jewish measures.

to 305, has been found to agree very nearly with that deduced from the lunar theory, of $\frac{1}{305}$, computed by Laplace, and the length of a degree on the meridian at the equator, from a comparison of the same data may likewise be considered equal to 60458 $\frac{1}{10}$ English fathoms. Admitting this to be the true amount of compression, and the radius of curvature at the equator, $R = \left(\frac{60458{\cdot}1 \times 113 \times 366}{355 \times 2}\right)$, $= 34639936$ fathoms, the length of the polar radius P, will be equal to $\left(\frac{R \times 305}{304}\right)$; and the length of the equatorial radius E, $= \left(\frac{R \times 305}{304}\right) + \left(\frac{R \times 305}{304,^2}\right)$: that is, $P = 34753883{\cdot}91$, $= \left(\frac{305 \times 34639936{\cdot}75}{304}\right)$; and since $\left(\frac{R \times 305}{304^2}\right) = \frac{P}{304}$, $= \left(\frac{34753883{\cdot}91}{304}\right) = 114354{\cdot}9$, the length of the equatorial radius, becomes $\left(114354{\cdot}9 + 34753883{\cdot}9\right) = 34868238{\cdot}8$ fathoms: hence the length of a degree, in latitude 45°, $=$ 60756·9 fathoms, consequently the meridional circumference 21872486·067432 fathoms; wherefore the two hundred thousandth part of a degree, as above, or $\frac{60756{\cdot}9057428 \times 6 \times 12}{200{,}000}$, or its equal, the seventy two millionth of the meridional circumference, $= \frac{21872486{\cdot}067432 \times 6 \times 12}{72{,}000{,}000}$, $= 21{\cdot}872486$ inches English.

The result of this computation differs about two hundred and nineteen hundred thousandths of an inch from that assumed as the true measure of the nilometer, or the molten sea: strictly, 21·874675179 ~ 21·872486 = ·002189112 inches, which is sufficiently near to exemplify the difference depending on this or that assumed ellipticity, or compression. So also, if it be taken according to Lambton, $\frac{1}{310}$, the degree on the meridian in latitude 45°, is 60751·8 fathoms, which would give 21·870648 inches English, for the two hundred thousandth part of the mean degree, or seventy two millionth of the whole circumference. Again, if we follow Lalande's compression, $\frac{1}{300}$, the length of a degree on the meridian in latitude 45°, is 60780·29 fathoms English measure, the two hundred thousandth part whereof is equal to 21·8809 inches English: from all which, it may be concluded with very great reason, that whenever the results obtained from the trigonometrical operations, undertaken in various parts of the earth, the lunar theory, the precession, nutation, and lastly, but more especially, the vibrations of the pendulum, shall be reconciled on the strictest mathematical principles, and concur to establish one uniform law of compression, to this, as to every other planet, we may then expect a perfect solution of a question which before hand we know to be founded in fact, but of which at present, we can hope only for an approximation.

To revert therefore to the remaining parts of our inquiry, itinerary and superficial measures. These may be defined in two several ways: the former, either with respect to the entire meridional or equatorial circumference of the earth, the mean length of a degree on the meridian, the equator, or the earth's polar, or equatorial axis; or lastly, the mean length of the second's pendulum throughout the earth, at a temperature commensurate with that of the greatest density of water, the measure of weight: the latter, or superficial measure with reference to the entire superficies of the globe, the superficial extent of the mean degree, or by means of the primitive standard or pendulum, in length and breadth, regulated as respects temperature, according to the foregoing rule. Such in fact, are the elementary principles of the itinerary and land measures, in all antiquity, from one or other of which all are undoubtedly derived.

First: itinerary measures derived from the earth's meridional circumference, or mean length of a degree on the meridian, in latitude 45°. The patriarchal or Jewish bereh, equivalent to the 24,000th part of the mean degree on the meridian; or in other words, 3000 measures of 21·874675179 inches, = 5468·668 feet, or 1822·889 yards: whence, Thales, Anaximander, Aristotle, successively, and long after them, Hipparchus, B. C. 140, derived their first opinions of the earth's dimensions, though they one and all, not only supposed this elliptic body to be a perfect sphere, which would occasion a very sensible altera-

tion in the necessary elements, but *doubted* of the truth of their informants, and suggested a better account, from their own fertile imaginations. The ancient Jewish or patriarchal parsah, or Arabian fursukh, the Grecian παρασαγγα, and Persian fursung, are three times the above measure; that is, 16406·004 feet, or 5468·668 yards, and these continued to be the received itinerary measures with all civilized nations down to the days of the Arabian Khalif Almamoon, though it must not be supposed, the principle was not therefore at any time perverted, or misunderstood, by the philosophers and speculative rhetoricians of Egypt and Greece, by Sanchoniatho, Berosus, and Aristotle, or their respective followers. Throughout the Turkish dominions at this present, the original itinerary measure of the 24,000th part of the earth's meridional circumference is still preserved under the name of berree, the same by which it was known to the Jews of old: and we may thus, by help of the first notices of the earliest heathen writings now extant, on the subject of the earth's dimensions, trace the gradual rise of all those contradictory statements which originated in a perversion, or misunderstanding of the original simple and comprehensive system of the patriarchs, till in short it was so mixed up with speculative reveries and astrological fictions, that in the days of Mamoon it became a serious question whether it had any real foundation in truth, being thenceforward replaced by the new and approximative experiment-

al measurements which do so much honour to the memory of that distinguished prince, and which were generally received from that period in all countries but Egypt and Turkey, where they subsist to this day.

The Greek philosophers in their wanderings had gained some little insight into these matters ; whether from the Egyptians, Chaldeans, or Indians, is an infinitely more conjectural idea than that they acquired it from the Jews, or other descendants of the patriarchs ; but whatever they may have learnt in this way, was a mere fragment of some simple and consistent scheme, to which, perfectly unconscious of its real value, they applied their own reasonings or fallacies with the exact degree of success that will ever attend the airy castles of theoretic speculation. Hence, Meton, Calippus, and Hipparchus, obtained celebrity for a more precise knowledge of the luni-solar cycles : Pythagoras, Democritus, and Eudoxus, for an acquaintance with the order and harmony of the planetary system, the existence of telescopic planets, as Mercury, and Saturn ; and in like manner, Anaximander, Thales, Hipparchus, and Ptolemy for a more just conception of the earth's dimensions, the obliquity of the ecliptic, the precession of the fixed stars, and the first elements of geography. But it is admitted on every hand, by astronomers, particularly by the most illustrious of the present day, that in all their writings there is a singular and unaccountable mixture of the most sublime

truths with irrational and inconsistent opinions, that do great discredit to their authors, if they constitute not a still stranger presumptive ground of doubt, whether these Grecian sages were indeed the discoverers of the arcana, which themselves maintained. What opinion in short is to be formed of this strange complication of truth and error, but that the former was either received, or borrowed, or surreptitiously appropriated, without acknowledgment, and so falling into the hands of persons perfectly incompetent to the estimation of its merit, was destined to the usual fate of ill-gotten wealth, to be soon lavishly wasted or deteriorated, to be descanted on from age to age, to be transmitted to posterity in a still more mutilated or disguised form, till its scattered fragments scarcely retained any one point of resemblance to the grand system whence they were derived.

Thales, B. C. 610, or his disciple Anaximander, appears to have furnished the statement to the Aristotelian school which that philosopher has given in his 2nd book de Cœlo: "All the mathematicians who have attempted by reasoning to discover the earth's circumference, affirm that it is 400,000 stadia." Mr. Delambre is of opinion that this remark of Aristotle neither establishes the true measure of the stadium itself, nor any real measure of the earth by ancient observations: estimating the circumference of the earth as stated, at 400,000 stadia, the stadium would be about 328 feet; which is considerably less than the

length generally assigned. It is worthy of remark that the four hundredth part of this stadium agrees exactly with the computation which I had deduced from the Soorya Siddhant, reputed to be the most ancient and correct astronomical book extant amongst the Hindoos: the length of the *nulwu*, translated furlong by Colebrooke, according to Amera Sinha, is 400 hustu or cubits. This cubit (so called), comes out = 9·84 inches; not by following their mode of reckoning, or we might suppose the Hindoo account to have been the production of as early an age as Aristotle, but by referring the Hindoo and Grecian data to actual experiments, or to the primitive patriarchal system. That is, in either case, these Hindoo and Grecian data, when submitted to either of these tests, give exactly half the measure resulting from actual experiment, while they professed, both one and the other, to give the full measure. It is to be presumed therefore that the Greeks were the real authors of this blunder in the first instance, which furnished the writers or compilers of the Poorans with the ground-work of the fable, that the circumference of the earth is 50,000 yojuns, for this is the reckoning at 8 *stadia*, or *nulwu*, to the yojun, an itinerary measure of 3200 cubits, conforming to that of Eratosthenes, Cleomedes and Posidonius, which was derived from their estimate of 252,000 stadia or furlongs to the circumference; each stadium of 320, or probably 400 cubits; the mile, or μιλιον, in both cases, being 3200 cubits in length; the

cubits in all the foregoing instances being the measures so called.

Domin. Cassini supposes Eratosthenes to have been the first geometer who had recourse to celestial observations, in order to determine the magnitude of the earth; and indeed the passage cited from Aristotle would seem to imply, that up to his time, 346 B. C. the ancient philosophers of Greece and Egypt, had merely speculated on the probability of some accounts received, or learnt, he knew not whence, or how. The measure of Eratosthenes, B. C. 210, was 700 stadia to the degree; that is, in round numbers, or 252,000 stadia for the whole circumference. Posidonius and Cleomedes computed it in like manner. Hipparchus, the prince of astronomers, as he is styled, B. C. 140, and after him, Ptolemy, A. D. 140, made it 8000 parasangs, 24,000 miles or 180,000 stadia; the παρασαγγα of 22½; the μιλιον of 7½ σταδια, or furlongs, each of 3000 measures. This latter opinion of Ptolemy referred most probably to some anterior geodesic operations between Racca, on the borders of Mesopotamia, and the celebrated "Tadmor in the wilderness," afterwards called Palmyra, where Solomon built a magnificent city and palace.

This last measurement was repeated by the Arabian Khalif, Al Mamoon: it had been reckoned by the earlier writers of that nation equal to 24,000 *meel mullikeen*, but Mamoon assigned 20160 meel, of 4000 *uswud dirʒa*, or black cubits, as they are

designated by Musoodee, the author of the *Mooroojood Duhub*, or "Pastures of Gold," epitomized by De Guignes, from a copy in the library of the king of France. All these measurements are considered by modern mathematicians to be more or less fictitious, or at best, but rude guesses. This appears to be the judgment of Mr. Delambre, as far as relates to that recorded of Eratosthenes. The distance from Alexandria to Syene, was reckoned to be 5000 stadia, which Eratosthenes had found to be contained under an arc of 7° 12′, on the terrestrial sphere, wherefore without adverting to the sun's true parallax, or the allowances due to refraction, he concluded this distance to measure also the fiftieth part of the earth's circumference. The circumference, at this rate, should have been 250,000 stadia; the degree of $\frac{5000}{7{\cdot}2} = \frac{50000}{72}$, or 694·444 stadia; to obtain the length of a degree of 700 stadia in round numbers, he assigned 252,000 stadia, to the circumference, and *in this very fact*, we have the strongest assurance that Eratosthenes never did measure the terrestrial arc, for the first was the true, the latter the incorrect account of the matter, as will be seen from what follows.

The Patriarchal bereh = 3000 measures, $= \frac{1}{24000}$ of the earth's circumference; the whole meridional circumference therefore = 72,000,000 × 21·874675179 = 131248,051·076 + feet. The Parsah, = three

bereh, or $\frac{1}{8000}$, of the earth's circumference. The Jewish *khebel*, or stadium = 400 measures. Aristotle's stadium = $\frac{1}{400000}$ of 72,000,000 measures, or 180 measures; but $180 \times 21{\cdot}874675179$, = 3937·441518 inches; that is, in other words, $100 \times 39{\cdot}37441518$ inches. By Eratosthenes' account, the stadium was $\frac{1}{250,000}$ of 72,000,000 measures; or in other words, 288 times 21·874675197 inches, that is, 6299·906428 inches; which is precisely equivalent to 160 times the measure deduced from Aristotle's stadium, or $160 \times 39{\cdot}37441518$ inches = 6299·906428 inches. In this preliminary investigation, we see the derivation of the measures of Aristotle and Eratosthenes from some one common statement, or their mutual agreement with it, and with each other: but 6299·9064288 inches, or 87·4987 fathoms, multiplied into 694·444 stadia to the degree, gives 60762·98 fathoms, precisely the same as the patriarchal, $= \frac{21{\cdot}874675179 \times 200,000}{6 \times 12} = 60762{\cdot}98$ fathoms. It can scarcely be affirmed after such explanation, that either of these philosophers appreciated, or in short, had the slightest comprehension of the subject, or they would never have suggested a preferable statement of their own: nor could Cleomedes and Posidonius have adopted such statement, had they known the real merits of the question delivered down by Eratosthenes. The subsequent ac-

counts of the latter are therefore to be considered mere unpretending transcripts of the error of Eratosthenes, for the stadium by his own shewing, was $\frac{1}{252,000}$ of 72,000,000 measures, or, 285·714 × 21·8746751, = 6249·9009 inches, or 173·6083 yards. How this was devised we may learn from the subsequent operations of Mamoon, for this prince either introduced, or it may be revised, the itinerary measure of Egypt, as he reckoned 20160 miles to the circumference of 4000 cubits each, (of the lineal standard,) there were 252,000 stadia or furlongs to the mile of 320 cubits each, *the mile of* ten such stadia, being 3200 cubits of the lineal standard ; and thus, by the abuse of the nomenclature and the confusion of tables arose all the contradictory opinions which disfigure and perplex the writings of the Heathens.

The itinerary measure of the Greeks and Romans instanced by Herodotus, Xenophon, Ptolemy, Diodorus, Strabo, Pliny, Quintus Curtius and others, of 30 stadia to the parasanga ; of 10 stadia to the mile ; of 300 measures to the stadium, as well that of Ptolemy of $\frac{1}{180,000}$ of the circumference, or $\frac{72,000,000}{180,000}$, = 400 measures × 21·874675179 = 243·05194 yards, were all borrowed in like manner from the patriarchal system ; and these, with the exception of the Roman *mille passus*, embrace all the authentic itinerary measures of antiquity. The Roman *mille passus*, as we have before shown, was nothing more than

a misunderstanding of the patriarchal *bereh;* for $\frac{16 \text{ digits} \times 5 \text{ feet} \times 1000 \text{ passus}}{3000 \text{ Jewish measure}}$, gives 26·666 digits for the length of each Jewish measure, and this stood in the ratio of 26·666 to 48, with respect to the forty millionth of the earth's meridional circumference; that is, 48 digits: 26·666 digits:: 39·37441518: 21·8746751 inches. The basis of the Egyptian, Chaldean, Greek and Roman itinerary measure, was the unit of the patriarchal scheme, that is 39·37441518 inches, the forty millionth of the earth's meridional circumference, to which the element of the patriarchal itinerary measure stood in the relation of 5 to 9; this last being the 200,000th of the mean length of a degree on the meridian in latitude 45°, or the 72,000,000 of the earth's entire polar circumference. Why the division by 48 or 28 was selected, remains to be explained, if it be not that these numbers presented the most commodious scales for general use; but the money weight of 60 shekels to the maneh, is remarkable for its affording greater facilities of sub-division than any other whatever; that is, taking either 10, or 12, or 100, or any other number soever, its multiples excepted, it was capable of division into more parts: for instance, the half, quarter, third, fourth, fifth, sixth, and so forth, could be taken, and with these fractions the deficient fractions made up; hence it is found to constitute a remarkable feature in the patriarchal tables of time, of 600 luni-solar years, which peculiarities

may possibly incline geometers to defer the division of the circle into six times the radius, or chord of 60 degrees, and the entire circumference of 360 degrees to the same source. The wisdom of the Chinese may be inferred from their discarding this simple division of the circle for that of $365\frac{1}{4}$ degrees: the French division, into 400, has probably undergone a sufficient ordeal in the fire of time to disprove its claims to supplant the ancient rules, but even these facts may weigh with many in behalf of the division we have so long been accustomed to follow, and which has the prescriptive right of so many thousand years' practical utility.

We have brought down the itinerary measures to the beginning of the Christian era. In the declining years of Rome, the fourth great monarchy of the world, literature and science dragged on slowly, after all that was celebrated in story, of that once powerful empire. From the time of Augustus, virtue and military prowess, and reputation for wisdom, were distinctions that subsisted only in the ideal greatness of Rome, and the records of past ages. The incursions of the Goths and Vandals aroused the nation to a sense of its fallen condition, and in a few years, the barbarians of the north were put in possession of all that constituted the empty title to such pre-eminence. It was long before they perceived the value of their acquisitions, and when Italy had in some degree recovered its energies, the Arabians had far out-stripped the scholars of the west in the career of intellectual glory.

Mamoon at the beginning of the tenth century of the Christian Æra, surpassing his father the celebrated Haroon-ool Rusheed, a name familiarly associated with eastern tale, in the accomplishments which then began at the termination of the Saracen conquests to distinguish the camps and courts of those destructive hosts, was at once the devoted patron and cultivator of every branch of learning. Pursuing the surest methods of investigating truth, by the abandonment or mistrust of every thing that was grounded on mere hypothesis or assertion, he diligently consulted the laws of the material world by experiment, and in the inductive analysis of such inquiries, arrived at the hidden foundations of that rational philosophy, the full development of which, at the interval of eight or nine centuries, has conferred lasting celebrity and honor on a Bacon, a Newton, and a Laplace.

Under the instruction of a Christian physician, by name Mesua, Mamoon assembled at his seat of government in Khorassan, many learned men, of all persuasions indiscriminately, Jews, Christians, and Mahomedans, for the better understanding and diffusion of his favorite pursuits, Astronomy and Mathematics more especially. In his passion for knowledge he entirely overlooked the bigotry of his creed, and evinced a spirit of toleration which was of singular advantage to the promotion of knowledge, although it gave great occasion of umbrage to his father. But he was soon relieved from uneasiness on this score,

by the death of Haroon-ool Rusheed, whom he succeeded in the Khalifat of Bagdad, in the 194th year of the Hegira, A. D. 809, being then only 23 years of age. Mamoon's predilection for literature and philosophy, contributed to raise him in the estimation of the best and wisest of his subjects, perhaps even in a less degree, than his clemency and justice in the opinion of the most lawless: for these qualities while they overawed, corrected and humanized the spirit of military adventure which glowed with unabated fervor in the breast of every Saracen soldier. A few years before his death, he caused Ptolemy's Almagest to be translated, which for a considerable period was the only knowledge we had of that work: with unparalleled industry and impartiality, he collected, arranged, and digested the scattered remnants of science that could then be obtained, at any expense or trouble, assisted in such research by the illustrious family of Moosa bin Shaker, Moohummud, Ahmud, and Alhazen. He determined the obliquity of the ecliptic to be 23° 33′ 52″. His attention was directed in the next instance to the magnitude of the earth, and other useful problems of a similar nature.

Two parties, the one headed by Khalid bin Abdool Mulik Murwuroodee; the other, by Alis bin Eesa Oostroolabee, measured a line under the same meridian, one party proceeding directly on the meridian, northerly; the other south of a central position, in the opposite direction; either as some relate, near Bhooyu Sinjar, in the neighbourhood of Moosul, the

ancient Nineveh; or, as others affirm, in the desert of Sinjyar, a dependency of the province of Diarrabia in Mesopotamia, until they found the altitude of the pole differ one degree from its altitude at the place of departure. The one assigned 56 Arabian *meel*, the others $56\frac{2}{3}$ to the length of a degree; the mean of these accounts, according to Mussoodee, was assumed as nearest the truth; Aboolfeda says 56. Another Arabian author, of whose work I obtained an extract by the favor of a learned Parsee priest in Bombay, Moolla Firoz, states that each result was rather less than 19 fursukh, (*tuqreebun*, that is, approximating to, but in defect;) now 56×360, = 20160 miles, each of which was of 4000 cubits, *(usuud:)* but the mean was something more, or 56·333 miles to the degree. Aboolfeda cites Ibn Kalikan, as we may see in his annals translated by Pococke, as his authority for these particulars, and that the ancient or patriarchal mile was of $66\frac{2}{3}$ to the degree, the circumference itself $66\frac{2}{3} \times 360$, = 24000 meel. The Arabian meel of Mamoon was therefore increased in the inverse ratio of 2016 to 2400. From the circumstantial detail of the operations, we have no reason to doubt the fact of its execution by the parties, as represented, neither of their acquaintance with the division of the circle into 360 degrees, the true ratio of the diameter to the circumference, nor the still more remarkable formula, or rule, for the exact computation of the earth's superficies: in all such indications of genuine experiment

and originality, the statements of the Greeks, Egyptians, Chaldeans, Hindoos, and Chinese, are altogether deficient*. The Arabian narratives make no

* *Abulfedæ Annales, Tom. II. page* 241 *to* 243. *Latine reddit. a Pococke.* "Eodem obiit Muhammed, filius Musæ, filii Schakeri, unus trium illorum fratrum, de quibus artes et inventiones mechanicæ filiorum Musæ in famam et proverbium iverunt, duo reliqui Ahmed et Hosain audiebant. Tres hi fratres magno cum studio et ingenti animo veterum philosophorum scientias excolebant, in primis geometriam, mechanicam, et musicam. His viris olim usus fuit Mamun ad explorandum terræ verum ambitum: didicerat enim ex antiquorum sapientium libris ambitum terræ viginti quatuor millia milliarium efficere. Cujus rei quo certior fieret, dabat his Musæ filiis in mandatis, ut, quantâ possent, maximâ curâ et diligentiâ in ejus rei veritatem inquirerent. Hi terras sibi dari poscunt in vastam porrectas planitiem, adeoque aptissimas observationibus instituendis; auditoque, desertum Sengarense, item humilius apud Cufam solum huic rei per-opportunum esse, proficiscuntur in planitiem Sengarensem, cum additis a Mamuno fidis inspectoribus et administris, qui observationes summâ cum circumspectione et fide peragi curarent, et peractas fuisse principi fidem facerent. Ibi diligenter quæsitâ inventâque poli elevatione, ad palum ibidem defixum alligant funem longissimum, et versus septentrionem primum, lineâ, quantum soli permittebat indoles, rectissimâ minimumque aberrante procedunt. Funis ubi desineret, ibi alium alii palo humi pariter depacto alligabant, donec id iterum iterumque repetendo, pervenirent ad locum ubi elevatio poli septentrionalis uno exactè gradu increverat. Id remensi spatium deprehenderunt, sexaginta sex milliaria, cum duobus milliarii trientibus conficere. Reversi ad locum, unde in septentrionem procedere cœperant, directe versus austrum procedebant, primo palo funem, et ita porro alios aliis alligantes, iisdem prorsus modis atque institutis, quibus antea versus boream procedentes, usi fuerant; donec tandem ad

parade of such knowledge, but introduce it casually as dependent on certain established mathematical processes: but by far the most ingenuous avowal, is that this geodesic operation of Mamoon professed no inventive stretch of genius, or novelty of thought, that it simply contemplated the verification of certain particulars derived from ancient books, which were proved to the perfect satisfaction of the prince and his coadjutors, by the mutual congruity of the several performances of the different parties with each other, and with the ancient observations. It is immaterial to the question, that the length of the

locum devenirent, in quo elevationem poli septentrionalis uno gradu humiliorem esse observabant. Id rursus emensi spatium rursus invenerunt sexaginta sex milliariûm esse cum gemino triente milliarii. Quibus peractis reduces Mamuno rationem sibi observatorum reddunt: qui, rei quam certissimi fieri posset, explorandæ ergo, Cufam eos mittit, ubi iteratis iisdem rationibus, quas in agro Sengarensi instituerant, quum eandem ibi pariter atque illic summam calculi darent, ad Mamunum renunciarunt: qui sic relationes, et hujus et ex antiquis libris haustæ veritatem planissime perspexit, ambabus observationibus cum vetustis, tum suis, exacte inter se congruentibus. Multiplicabant deinde sexaginta sex, et quod excedit, cum 360, quot sunt gradus orbis cœlesti, unde confecta viginta quatuor milliariûm millia. Hæc ita hâctenus retuli ex Ibn Chalicani et aliorum historicorum fide; quos tamen dubio vacat in eo falli, quod existimant Mamuni tempestate inventum fuisse, sex et sexaginta milliaria cum gemino triente unicuique gradui competere. Tantundem enim numerarant veteres in gradum: at Mamuni tempore observatum fuit, gradus singulos non habere nisi quinquagena et sena milliaria. Id quod demonstratum est in astronomicis."

degree was not determined with the exactitude of modern science: the methods to which Mamoon had recourse were theoretically correct, the instruments however, with which the experiments were conducted were much too rude to give results nearer the truth than those of 56, $56\frac{1}{3}$, or $56\frac{2}{3}$ Arabian meel: it may be observed in this place, that the extremes differed exactly one eighty-fifth of the contained arc.

The tide of conquest and migration effected an early diffusion of the science and literature of the Arabians throughout the whole of Asia; the Tatars applied them to their legitimate uses, but the Hindoos and Chinese surreptitiously appropriated them for a very different object. The priesthood availed themselves of every thing they could lay their hands on, or comprehend, to aggrandize themselves in the eyes of the multitude, by the fabrication of a very plausible scheme of chronology and astronomy, embracing periods of time beyond the utmost comprehension of sober reasoning. The rise of this system of priestcraft, both in China and India, which had hitherto eluded the research of Bentley, Wilson, Colebrooke, and Sir William Jones, has been satisfactorily traced to the 607th year of the Christian era, but this is no fit place to state the proofs, which belong to a distinct inquiry; the astronomical fictions were framed subsequent to the propagation of the existing religions of the worshippers of Brahma and Fo; on the introduction of these astronomical fictions it became necessary to remodel their chronology.

The Hindoo shasturs, it must be admitted by their most strenuous advocates, speak as little for the consistency and penetration of their Reeshees and astronomers as for their morality and wisdom: in the articles of imagination and morality indeed, they are gross and degraded beyond those of all other idolatrous nations. Their astronomical works furnish us with the first proof of this appropriation of Arabian science: to elucidate this fact is easy, and may be sufficient for the present argument. These works differ widely in the measure assigned to the earth's circumference; according to seven of the eighteen Siddhants, held most in repute, the diameter and circumference are as follows: Sooryu Siddhant, the oldest and most esteemed treatise, the circumference = 5059, the diameter = 1600 yojuns: according to the Siddhant Shiromunee of Bhaskur Acharyu, the circumference = 4937, the diameter $=1581\frac{1}{14}$ yojuns: according to the Lughoo Vasishta Siddhant, the circumference = 4966, the diameter = 1581 yojuns: according to the Siddhant Shekhur, the circumference = 5000, the diameter 1581 yojuns: according to the Sarwu Bhoom Siddhant, the circumference = 5026, the diameter 1600 yojuns: according to the Lullu Siddhant, the circumference = 3300, the diameter = 1050 yojuns: lastly, according to the Arya Siddhant, used in the south of India, the circumference is equal to 6625 yojuns. These citations are sufficient to show that the Hin-

doos are not agreed, as is generally affirmed, in the matters which they severally maintain to have been revelations from a higher source; but for the confirmation of the present point at issue, we may discuss the merits of those dimensions stated in the Sooryu Siddhant, which is reputed to have the precedence of every other Hindoo treatise of Astronomy, both in antiquity and accuracy. The original passage is thus closely rendered: "The diameter of the earth is twice 800 yojuns. The square root of ten times the square of that sum is the earth's circumference." That is, numerically, 800×2, = 1600; which squared, = 2560,000; this multiplied by ten = 25,600,000, the square root of which is 5059·64425 yojuns, or 5059 yojuns, 2 kos, 1154 dundas, and since the Hindoos divide the circle, *(vrith* or *wurtool,)* into 360 parts or degrees, *(ounsh,)* the three hundred and sixtieth part of the circumference is equal to one degree, = $\frac{5059 \cdot 64425}{360}$ = 14·05459 yojuns, or multiplying it by 4, there being 4 kos to a yojun, = 56·21828 kos in a degree, which corresponds as nearly to the measurement of Mamoon, as the empirical ratio of the diameter to the circumference might lead us to expect. From a review of this, and the several statements, two things are manifest, that the Hindoos did not know the true ratio of the diameter to the circumference, which they have reckoned variously: in the foregoing instance, as, 1 to 3·162277; an

approximation or guess, for aught we know to the contrary, unsupported by mathematical proof; and next, that the account in question was borrowed, because it does not agree with the practical system of measures which prevail all over India, and which the Hindoo shasturs inform us is equally ancient. These books inform us, little adverting to the purpose to which the information would one day be applied, that the kos is a measure of 8000 cubits; supposing this to be true, and the statement in the Sooryu Siddhant original, $8000 \times 56{\cdot}21828 = 449746{\cdot}24$ cubits, should represent the length of a degree, and the length of the cubit, computed from this, $= \frac{60762{\cdot}9 \times 6 \times 12}{449746{\cdot}24} = 9{\cdot}7$ inches English; exactly the half of the cubit of 14 tussoos; or 24 digits, throughout all parts of India, because forsooth it is purposely disguised to preclude the detection of the plagiarism. It is well known that Mr. Davis has asserted in the Asiatic Researches, in an essay on the Astronomy of the Hindoos, that as the radius in the table of sines found in the same book, but a few lines further on, is made to consist of 3438 equal parts or minutes, of which equal parts the quadrant contained 5400, this implies a much more accurate knowledge of the ratio of the diameter to the circumference, viz. 1 to 3·14136, but this only serves to corroborate the opinion of the Hindoos being mere copyists at second hand from the Arabians and Greeks, for what could possibly be a more palpable indica-

tion of plagiarism, than to find a false rule placed side by side with another that is true, and both mixed up in all sorts of ways, in the calculations of eclipses, the positions of the planets, and so forth, as the production of one author, let us not so grossly abuse the appellation, as to call him a *mathematician?* Again, for the second difficulty, on examination of the table, we discover a nearer ratio even than the foregoing, and why not have used the true length of the radius, 3437'74? are they not the inventors of the decimal scale !! But if they be not entitled to that honor, at least they have elsewhere resorted to the ancient practice of taking up fractions by multiplying the whole number into the denominator of the fractions, as in the case of the great year, computed from a complete revolution of the equinoctial colure. Mr. Delambre has entered into a long and learned defence of the Hindoo table of sines in the Connoissance des Temps for 1808, page 447; notwithstanding, having entirely overlooked the former objection, namely, the previous mention of an untrue ratio, the case must necessarily stand by itself, to be judged as the production of another author.

The Chinese have likewise availed themselves of this same measurement by the Arabian Khalif Mamoon; the Jesuits Martini, Noel, Parennin, Gaubil, and Verbiest, have left us sufficiently detailed particulars in that strange medley the Lettres Edifiantes, from which to judge of the merits of the proficiency of the Chinese in science. Pere Gaubil reports, that

their ancient astronomers measured several arcs of the meridian, in order to determine the number of *li* to a degree. Under the Emperor Huien Tson, who is said to have reigned from the year of our Lord, 712 to 756, one of the greatest astronomers in China, by name Yhan, measured several spaces on the plains of the province of Honan, which lie almost entirely south of Hoanho, or the yellow river. The first of these, by the difference of observed altitudes, of $29\frac{1}{2}$ minutes of latitude, was found to be 168 li, 179 pu; another of $29'50''$, contained 167 li, 241 pu; a third arc of $28'34''$, contained 160 li, 10 pu. In which it is to be noted, that in these differences of latitude, the graduation is reduced to the European, from that in use among the Chinese, for they divide the circle into $365\frac{1}{4}$ degrees, analogously to the division of the solar year, and assign therefore to the graduation of the meridional arcs between the equator and poles, 91 $\frac{5}{16}$ degrees: though the practice has probably fallen into disuse, with many other such fanciful devices, since the introduction of the Jesuits into the Chinese tribunal of mathematics. From the first of these, he concluded the degree, or three hundred and sixtieth part of the circumference, to be equal to 340 li: from the second, 338 li; from the third, 336 li.

The results of a similar operation carried on about the year 1000 of the Christian era, gave, as we are told, by Danville, from the memoirs of the Chinese re-

ported by the Jesuits, one thousand li to three Chinese degrees of latitude, which reduced according to the foregoing graduation gives 338·278 li for each degree, or the three hundred and sixtieth part of the circumference. That is, 3 Chinese degrees : 365·25 Chinese degrees :: 1000 li : 121750 li ; the 360th part whereof, = 338·278 li : what other data Danville may have had to obtain these results, does not appear, but the numbers 340 ; 338; and 336; are exactly in the same ratio as the measures of Mamoon ; $56\frac{2}{3}$, $56\frac{1}{3}$, and 56 : hence the li comes out = 1000 Arabian feet, and six li, 4000 Arabian cubits, (each of 19·4022 inches English,) for $\frac{4374497 \cdot 2134816 \times 360}{1217 \cdot 50 \times 1000}$ = 12·93486 inches English. As the Arabian astronomers were divided in their estimate of 56, and $56\frac{2}{3}$ Arabian meel to the degree, or the 85th part of the contained arc ; so also, the Chinese and Hindoos demurred on this very same point, which in the absence of more direct evidence must be considered a very notable proof of their being all one and the same account.

To this epocha also we may trace the introduction of itinerary measures into European countries conforming more or less to the Arabian and patriarchal. The itinerary measures of the Tatars, Huns, Moguls, Saracens, are of Arabian origin ; and are found in Spain, Portugal, Morocco, Russia, Persia, and according to the injunctions of the Mahommedan sovereigns, in India likewise. The old system of the French was a measure of 2000

toises, or 12,000 feet, or 8000 primitive cubits of 19·32 inches, the very same as the Hindoo kos. The Spanish legua of 8000: the Portuguese of 5000 varas, or guz of 24 (tussoos), parts of the second scale, or division of the primitive standard into 28 parts: the kos established by the Emperor Akbar in Hindoosthan, also of 5000 guz, of the same length, (24 tussoos,) the measure of England, = 8 furlongs of 400 cubits, or 3,200 cubits of 19·8 inches.

It now remains only to show the origin of the superficial measures of antiquity, and their connection with the scientific elements of the patriarchal system. From the testimony of Herodotus, Josephus, and the historians cited by him, in his discourse against Apion, we learn that the measure called the αρουρα was common to the Greeks, Egyptians, and Jews; it was a square of 100 measures, = 4785014·4 inches, or 3692·1 square yards, which was equivalent to the four-millionth part of the mean superficial extent of a degree on the earth's surface. By dividing the whole surface of the earth, therefore, which for the present argument we may suppose equal to 196,862,256 square miles, as it is said to have been determined by Laplace, or its corresponding area reduced to square yards, = 609,800,524,185,600, by the number of square degrees, we have

$$\frac{609,800,524,185,600}{E\,P\,c \times \left(1 + \frac{1 \times E^2 - P^2}{6\,P^2} - \left(\frac{E^2 - P^2}{40\,P^2} \times \frac{E^2 - P^2}{P^2}\right) + \&c.\right.}$$

= 14765529391·33 square yards, the four millionth

part whereof, $= (100 \times 21{\cdot}87242)^2$; and the square root, supposing the degree a perfect square, 60756·7 fathoms*. But whatever elements are had recourse to, we shall find the differences between the four millionth part of the total number of degrees on the earth's surface, to be too inconsiderable to affect the quantity, or area of the aroura, beyond the last figure. Suppose, for example, the length of the degree in latitude 45°, = 60762·986, as derived from the Jewish ; or from a comparison of the British, Lapland, Indian, and French surveys, = 60756·9057428 ; or with Lambton, 60751·8 ; or, lastly, with Lalande, 60780·29 fathoms, the measure or superficies of the *aroura*, will be in each of the several cases as follows :

	Superficial extent of the Aroura.	Sq. Yds.
From the Jewish computation of the earth's surface = ...		3692·1
From a comparison of European and Indian surveys = ...		3691·4
From Col. Lambton's Indian survey, ..		3690·78
According to Lalande, ..		3694·0
According to the account given as Laplace's in Barlow's Mathematical Dictionary, ..		3695·6

The elementary measure, as we have shown, was the 200,000th part of a degree on the meridian, in latitude 45°, in the exact ratio of 5 to 9, with respect to the forty-millionth of the whole polar circumference ; for this last being 48 digits, or for the sake of illustration, so divided, $26\frac{2}{3}$: 48 digits : : 80 : 144 or as 5 : 9, that is, in each of the foregoing instances,

* I have computed the earth's surface according to Professor Airy's statement of the axes before mentioned, the earth being considered a regular oblate spheroid = 609,919,391,835,634·919 square yards.

1st. The forty and seventy-two millionth of the first or Jewish will be, ...	The seventy-two millionth	21·874675	The forty millionth of the earth's polar circumference.	Inches. 39·37441
2nd. From comparison of European and Indian surveys,.....		21·872486		39·37047
3rd. According to Lambton's survey,....		21·870648		39·36716
4th. According to Lalande's computation,		21·8809		39·3856
5th. Laplace's as above deduced from the surface, ...		21·87242		39·37035
6th. According to the French survey,....		21·872664		39·37079

The next most remarkable land-measure was that of 100 cubits each way, or 10,000 square cubits of the primitive standard, which was equal to the five millionth part of the mean superficial degree, or nearly so, therefore in the ratio of four to five, with respect to the aroura. For example (19·54893 inches ×100) squared = 2948·77 square yards, five million times which area gives 14743850000·0 square yards for the mean superficial degree, and for the total surface of the earth, 608,895,510,000,000 square yards: by using the computed surface of the earth, said to be that of Laplace, the result differs immaterially being $\frac{609,800,524,185,600}{41298255 \times 50,000}$ square yards, = 2953·1 square yards.

This superficial land-measure, of ten thousand square cubits, is readily identified with the Roman jugerum, the candetum of the ancient Gauls, specified by Columella, the Persian jureeb, and the beegah of Hindoosthan. Columella (*de re rustica*, lib. 5, cap. 1): tells us that the candetum, a land-measure used by the ancient Gauls, was 150 feet each way, or in other words, it was square of 100 cubits, by the reduction of the former in the ratio of 3 feet to 2 cubits. Varro and Columella describe the Roman

jugerum as a superficial measure, 120 feet by 240 feet, (Roman account,) that is, reduced in the ratio of three to two, of 80 cubits, by 160 cubits or 12,800 square Roman cubits; hence by analogy we obtain the correspondent cubit, one hundred of which, being squared, represent also the same superficies, $\sqrt{12800}$: $\sqrt{10,000}$ :: 17·4 inches (the assumed length of the lineal measure called by the Romans a cubit): 19·68 inches; or thus, 240 times 11·6 inches English, (the length of the Roman foot, according to Dr. Greaves,) $\times 120 \times 11{\cdot}6$ inches English, $=$ 387·5328 the square root of which, is 19·68 inches.

The Persian jureeb is a measure of 50 arish squared, the arish agreeing with the primitive standard, or twice the primitive cubit. The Indian beegah is a measure of 20 gunthas, kottahs, vansas or kathees, each way, the length of such land-measuring rod in Hindoosthan proper, and all India north of the Nurbudda, being of five cubits, (the Indian cubit agreeing by experiment with half the primitive standard of the sanctuary,) consequently a square of one hundred cubits each way. Besides

* Here it should be observed, that the difference of temperature at which the standards are taken by Professor Airy in his measurements of the earth's axes, will compensate for the difference between the measures of superficies computed from his data and the primitive standard, the four millionth of Professor Airy's mean degree would be 3692·1 square yards; the five millionth equal to 2953·73 square yards: the double of the hundredth of the square root of the latter is 39·1307 inches.

these, there are other land-measures in India of 80 cubits squared, or 6,400 square cubits also of $5\frac{5}{8} \times 20$ or $116\frac{2}{3}$ cubits squared, or square cubits, but these as far as I can learn, are found only to the south of the Nurbudda, which river divides Hindoosthan from the peninsular countries to the south of it, distinguished at some remote period by one general name, the Dukhshun or Dukhun (south).

The measure of the Persian King Noorshirwan, under whose reign the Arabian prophet Mohummud was born, was a square of 60 kissery guz, or 3600 guz; it was introduced into India by the Emperor Akbar, and is noticed by Sir John Malcolm in his Memoir of Central India, as the prevailing land-measure of Malwa: these as we learn from historians were novel inventions of those sovereigns, they were of 11,025 square cubits. The English acre which was fixed by statute in the 33rd and 34th year of the reign of Edward the First, is a measure of 16,000 square cubits, or a square of 400 cubits: the cubit 19·8 inches, as before. The French arpent ordinaire of the old system, 900 square toises, or 14,400 square cubits; the cubit supposed equal to 19·2 inches. The arpent royale, 12,100 square cubits, the cubit itself the same as the preceding. The Scottish acre regulated by the elwand, established by King David the First, and kept in the council of Edinburgh, being to the English, as 7869 to 10,000 or 1259 to 1600; supposing the English and Scottish measures of the cubit the same: it was ten

times the square of 24 elwands, or 5760 square elwands: but this last measure being found on examination to contain 37·2 inches English, and representing a measure of 45 digits, when reduced in the ratio of 24 to 45, gives 19·84 inches for the cubit, the Scottish acre therefore by this would be 20,250 square cubits.

Having adduced sufficient instances in proof of the fact that all itinerary and superficial measures referred either to the measure derived from the earth's dimensions, or to the primitive standard, it remains only to be observed, that it is impossible, without the most perfect data, to say whether any or what relationship exists between the measure derived from the earth's superficies, or its circumference, and the pendulum vibrating seconds in a mean solar day; but in the analogy of the land-measure, founded on the latter to the Aroura, there would seem to be some grounds for its reality, because these areas are in the ratio of 4 to 5, nearly, and the hundredth of the square root of the Aroura to the forty millionth of the earth's circumference is as 5 to 9: agreeable to this, the mean length of the second's pendulum would be to the former as 5 : $\sqrt{20}$, or the three hundred and sixty millionth part of the earth's meridional circumference into the square root of 20; the forty millionth, and seventy-two millionth, being respectively denoted by 9 a, and 5 a, the second's pendulum by a $\sqrt{20}$: computing for example with the French data; first, the

forty millionth of the earth's periphery = 39·37079 inches English, which reduced in the ratio of five to nine is 21·872664; this last squared, and reduced to square yards, is 3691·461654, which reduced in the ratio of four to five, the analogy of the superficial measure of 100 cubits squared, to the square of 100 times 21·872664, is equal to 2953·16932381 square yards; the square root of which divided by 100, and multiplied by 2, is 39·127010 inches; this supposes also the mean superficies of a degree = 14,765,840,000 square yards, and the total surface = 609,803,990,000,000 square yards.

Since the laws of gravity which regulate the lengths of pendulums, and the descent of falling bodies, describing certain spaces in certain times, or in fact, the ratio of the force of gravity, that is, of a heavy body falling through half the length, to the times of oscillations of any pendulum, are strictly analogous to the ratio of the diameter to the circumference of a circle, why may not the same, or some very similar relationship be expected to subsist, between the length of a pendulum which vibrates seconds or other portions of time, and a mean measure of the earth's dimensions expressed in terms of such pendulum, considering the earth to be strictly as an oblate spheroid?

In this essay, there is sufficient argument to dissuade those who cultivate science from pronouncing hastily against any passage of scripture, though the solution of its difficulties be far from obvious. In-

numerable indeed are the truths of a far less abstruse nature, which are immeasurably removed from those who will not be at the pains to examine them : inasmuch also, as the test to which we submit any observation is imperfect, the inference must be in a like degree unsound. Secondly, to repel, or rather disprove the mere assertion, that the Egyptians, Chaldeans, Indians, Chinese, or the philosophers of Greece originated so much as one new idea, unless evidence to the fact can be produced from their writings, or such other indications as usually accompany and mark the progress of genuine discovery. Thirdly, to shew that the most enlightened sages of antiquity, Pythagoras and his school ; Thales, Aristotle, Eratosthenes, Archimedes, Hipparchus, Ptolemy, and their disciples respectively ; and last in order of time, the Arabians and Tatars, with their copyists, the Chinese and Hindoos, were altogether indebted for the few imperfect hints which they had picked up from age to age, from the Jews, in this department of mathematics. Finally, to illustrate the universality and simplicity of the scriptural scheme of metrology, which combines unity of design, with great and peculiar recommendations to its acceptance, of which it cannot be judged the least, that it embodies the very choicest elements which have been selected as the ground-work of the French and English systems. Added to this, is the singular advantage of experience ; as to the practical working of the original principles, in the teeth of human devices for their

annihilation or alteration. The system we have investigated, although sadly defaced, is not yet entirely demolished ; it still towers triumphantly over every other throughout the world, as a venerable and glorious ruin, to be restored perhaps to its former grandeur by those very nations whose aim and interest are as inseparable, as their existence and glory are co-extensive. In presenting this sketch of a very singular and ancient structure, and digging its remains out of the mass of rubbish and weeds which had been accumulating around it for ages, it can hardly be thought a reproach to have failed in pointing out some excellencies, or to have escaped some erroneous impressions. Whether the ratio of the length of the second's pendulum to the earth's meridional circumference be any thing better than a mere approximation to the truth, a point indeed, which if proved, would be chiefly important as it affected the probability that science came originally by inspiration ; it may safely be affirmed, that the chances are infinite against any two or more particulars agreeing so very nearly with experiment by mere accident, more especially when such particulars are determined with respect to the complicated schemes of metrology, of kingdoms and people separated from each other, not only by vast intervals of time, but of civilization and space. It were equally repugnant to sound reason and historical testimony moreover, to conclude, that an explanation of all those difficulties which are no otherwise to be removed in

regard of the metrological systems of all other nations, should be incidentally given in a statement which strictly fulfils the preceding conditions, according to the uncompromising test of mathematical argument, and, no less unanswerable that the Jewish nation must have possessed a perfect understanding of all the details on which it was founded: that their acquaintance with it must have been long antecedent to that of the Egyptians, Chaldeans, Indians, Greeks, and Chinese, who otherwise could not have been so unwise as to question its truth, differ about its application, or betray their own narrow-mindedness and ignorance in attempting to substitute a false one in its room, neither can it be doubted that they would have declared the grounds of their opinions, or suffered them in some shape to transpire, had they any of their own, or even a clear apprehension of them from others, at second hand, to produce to the admiring world. Lastly, no less remarkable and instructive is the sum of the whole argument, that mathematical science was, some five thousand years ago, but little short of its present perfection, with respect to that branch of it now under discussion; admitting that no better case can be made out in regard to others: that it has declined with the decline of true religion; that the energy, yet more the sobriety; the freedom, yet much more the restraints which its returning light has inspired, has operated to dispel the delusive dreams of the dark ages of superstition, to remove the veil of

intellectual and sensual idolatry, to increase our happiness, to enlarge our views, to meet our wants, to subserve, in short, the great end of our existence, in proportion as we lean not on our own limited understandings, but advert *first* and *last* to " the Giver of every good and every perfect gift."

FINIS.

APPENDIX.

[NOTE.—The following is the passage from Babbage on the Decline of Science, referred to in the Preface, page viii.]

"The singular minuteness of the particles of bodies submitted by Dr. Woollaston to chemical analysis, has excited the admiration of all those who have had the good fortune to witness his experiments; and the methods he employed deserve to be much more widely known.

It appears to me that a great mistake exists on the subject. It has been adduced as one of those facts which prove the extraordinary acuteness of the bodily senses of the individual—a circumstance which, if it were true, would add but little to his philosophic character; I am however inclined to view it in a far different light, and to see in it one of the natural results of the admirable precision of his knowledge.

During the many opportunities I have enjoyed of seeing his minute experiments, I remember but one instance in which I noticed any remarkable difference in the acuteness of his bodily faculties, either of his hearing, his sight, or of his sense of smell, from those of other persons who possessed them in a good degree. He never showed me an almost microscopic wire, which was visible to his and invisible to my own eye: even in the beautiful experiments he made relative to sounds inaudible to certain ears, he never produced a tone which was unheard by mine, although sensible to his ear; and I believe this will be

found to have been the case by most of those whose minds had been much accustomed to experimental inquiries, and who possessed their faculties unimpaired by illness or by age.

It was a much more valuable property on which the success of such inquiries depended. It arose from the perfect attention which he could command, and the minute precision with which he examined every object. A striking illustration of the fact, that an object is frequently not seen, *from not knowing how to see it*, rather than from any defect in the organ of vision, occurred to me some years since, when on a visit to Slough. Conversing with Mr. Herschel, on the dark lines seen in the solar spectrum by Frauenhofer, he inquired, whether I had seen them; and on my replying in the negative, and expressing a great desire to see them, he mentioned the extreme difficulty he had had even with Frauenhofer's description in his hand, and the long time which it had cost him in detecting them. My friend then added, I will prepare the apparatus, and put you in such a position that they shall be visible, and yet you shall look for them, and not find them; after which, while you remain in the same position, I will instruct you *how to see them*, and you shall see them, and not merely wonder you did not see them before, but you shall find it impossible to look at the spectrum without seeing them.

On looking as I was directed, notwithstanding the previous warning, I did not see them; and after some time, I inquired how they might be seen, when the prediction of Mr. Herschel was completely fulfilled.

Temperature of the Maximum Density of Water.

An elaborate memoir by Professor Hällström, on the specific gravity of water at different temperatures, and on the

temperature of its maximum density, has appeared in the Swedish Transactions for 1823. It is divided into two parts: the first contains a critical discussion of the results, and the methods employed by preceding experimenters; the second, a detail of an extensive course of experiments, instituted by himself, with a view to the more accurate determination of this important but difficult inquiry. The method of experimenting which he regarded as the most accurate, and which he therefore adopted, was to ascertain the weight of a hollow glass globe, very little heavier than water, and about 2¼ inches in diameter, in water of every degree of temperature between 0° and 32·5° centig. The errors arising from a dilatation or contraction of the glass, the weight of the atmosphere, &c. were all calculated, and a corresponding correction made. The result was, that water attains its greatest density at a temperature of 4·108° cent. (39·394° Fahr.); and the limits of uncertainty occasioned by the impossibility of ascertaining the dilatation of glass with perfect accuracy, he estimates to be 0·238° (0·428° Fahr.) on either side of this number.

The two following tables exhibit the result of his experiments on the sp. gr. of water in all temperatures between 0° and 32° centig. In the first, the sp. gr. at 0°; in the second, the sp. gr. at 4·1° is taken as the unit.

Temperature.	Specific Gravity.	Temperature.	Specific Gravity.	Temperature.	Specific Gravity.
Cent.		Cent.		Cent.	
0°	1·0000000	10°	0·9998906	21°	0·9983648
1	1·0000166	11	0·9998112	22	0·9981569
2	1·0000799	12	0·9997196	23	0·9979379
3	1·0001004	13	0·9996160	24	0·9977077
4	1·00010817	14	0·9995005	25	0·9974666
4·1	1·00010824	15	0·9993731	26	0·9972146
5	1·0001032	16	0·9992340	27	0·9969518
6	1·0000856	17	0·9990832	28	0·9966783
7	1·0000555	18	0·9989207	29	0·9963941
8	1·0000129	19	0·9987468	30	0·9960993
9	0·9999579	20	0·9985615		

Temperature.	Specific Gravity.	Temperature.	Specific Gravity.	Temperature.	Specific Gravity.
Cent.		Cent.		Cent.	
0°	0·9998918	10°	0·9997825	21°	0·9982570
1	0·9999382	11	0·9997030	22	0·9980189
2	0·9999717	12	0·9996117	23	0·9978300
3	0·9999920	13	0·9995080	24	0·9976000
4	0·9999995	14	0·9993922	25	0·9973587
4·1	1·0000000	15	0·9992647	26	0·9971070
5	0·9999850	16	0·9991260	27	0·9968439
6	0·9999772	17	0·9989752	28	0·9965704
7	0·9999472	18	0·9988125	29	0·9962864
8	0·9999044	19	0·9986387	30	0·9959917
9	0·9998497	20	0·9984534		

The uncertainty which still exists respecting the temperature of the maximum density of water may, perhaps, be best illustrated by a table of the results, which he brings successively under review.

Observer.	Calculator.		Observer.	Calculator.	
		Cent.			Cent.
De Luc,	Biot, ...	3·42°	Charles, ...	Biot, ...	3·99°
	Ekstrand, ...	3·60		Paucker.....	3·88
	Paucker, ...	1·76	Lefevre Gineau,	LefevreGineau,	4·44
	Hällström, ...	1·76	Hällström, ...	Hällström.....	4·35
Dalton, .	Dalton, ...	2·22	Bischof, ...	Bischof, ...	4·06
	Biot, ...	4·35	Rumford, ...	Rumford, ...	4·38
Gilpin, ..	Young, ...	3·89		....	3·47
	Biot, ...	3·89	Tralles, ...	Tralles, ...	4.35
	Eytelwein, ...	2·59	Hope, ...	Hope, ...	3·33
	Walbeck, ...	0·44		....	3·88
	Hällström, ...	3·82		....	4·16
	Eytelwein, ...	2·91	Ekstrand, ...	Ekstrand, ...	3·60
	Hällström, ...	8·63	....	....	3·90

Before commencing his investigation, Prof. H. determined in the first place the dilatation of the glass which he employed in the course of his experiments. His results, particularly in the two extremes of temperature, differ considerably from those of Lavoisier and General Roy; on which account, we consider it worth while to insert them here."

Temperature.	Expansion.	Temperature.	Expansion.
Cent.		Cent.	
0°	0·000000	60	0·000496
10	0·000030	70	0·000652
20	0·000181	80	0·000829
30	0·000153	90	0·001027
40	0·000246	100	0·001246
50	0·000361		

See Annals of Philosophy, for February, 1825. page 155.

" Of all liquids, that which has been most carefully and most minutely examined with respect to its dilatation, and which presents the most striking exception to the general law of expansion, is *water*. All the methods which have been explained have been applied to this liquid, and all concur in proving, that as its temperature is lowered towards the point at which it is converted into a solid, its contraction does not proceed in the same uniform manner as the general law would lead us to conclude. As its temperature is lowered, the rate at which it contracts is observed to diminish, until it arrives at about 39·2° of the common thermometer. Here all contraction stops, and if the temperature be lowered, it is observed, that neither contraction nor expansion takes place for some time; but, presently, on lowering the temperature still more, a dilatation is observed to be produced, instead of a contraction; and this dilatation continues at an increasing rate, until the water is frozen." " It appears, therefore, that water has a point of maximum density, and that that point is at the temperature of about 39·2° Fahrenheit. Different philosophers have determined the point of greatest condensation, and the results of their investigations very nearly agree. Sir Charles Blagden and Mr. Gilpin fixed it at 39°. Lefevre Gineau, by very accurate experiments, fixed it at nearly 40°. More recently, Hällström arrived at a similar result. Experiments, performed by Dr. Hope and Count Rumford, agree in fixing the point of maximum density between 39° and 40°. The experiments of Hällström fix it at 39·38°. For a few degrees above and below the temperature of greatest condensation, the dilatation of water is found to be the same. Thus, at 1° above and 1° below the point of greatest condensation the specific gravities of water are the same, in like manner as 2° above and below that point of specific gravity are exactly equal. This, however, extends only through a very small range of temperature."

"In a question of such importance in physics, as the temperature of water at its extreme state of density, it is not wonderful that every contrivance which philosphical ingenuity could suggest for the attainment of accuracy should be resorted to. In all the methods for the determination of the dilatation of liquids, which have been here explained, the previous accurate determination of the dilatation of the vessels, containing the liquids, or immersed in them, must be previously known. A method, however, independent of this, has been suggested and attempted, for ascertaining the temperature of water in its extreme state of condensation. This method rests upon the principle that liquids of different specific gravities, when mixed, will arrange themselves in the order of their weights, the heaviest taking the lowest position. If different portions of water be contained in a vessel, at different densities, the most dense will, therefore, settle itself at the bottom. This principle was applied by Dr. Hope, of Edinburgh, and also by foreign philosophers, in the following manner:

"Tall cylindrical glass jars were filled with water at different temperatures, having thermometers suspended in them at the top and bottom. When the water at 32° was exposed in an atmosphere at 61°, the bottom thermometer rose faster than the top, until the water arrived at the temperature of 38°. After that, the top thermometer rose faster than the bottom. When the water in the jar was at 53°, and was exposed to colder water, surrounding the vessel, the top thermometer was higher than the bottom, until the water in the jar was cooled down to 40°, and then the bottom thermometer was higher than the top. It was hence inferred, that when water was heated towards 40°, it sunk to the bottom, and that above 40° it rose to the top, and *vice versâ*. When a freezing mixture was applied to the top of the glass jar, at the temperature of 41°, even though its application was continued for several

days, the lower thermometer never fell below 39°; but when the freezing mixture was applied at the bottom, the upper thermometer fell to 34° as soon as the lower one. It was hence inferred, that water, when cooled below 39°, cannot sink, but easily ascends. When the water in the jar was at 32°, and warm water was applied to the middle of the vessel, the thermometer at the bottom rose to 39° before the thermometer at the top was affected at all; but when the water in the cylinder was at 39·5°, and cold was applied to the middle of the vessel, the thermometer at the top fell to 33° before the lower thermometer was affected."

"Water, in its state of greatest condensation, has been adopted by the French as the basis of their uniform system of measures. Their unit of weight is called a *gramme*, and it is the weight of a cube of distilled water taken in its state of greatest condensation, the side of the cube being the length of a *centimètre*, or the one-hundredth part of their unit of measure which is called a *mètre*, the length of which is 39·3702 English inches."

"If the weight of distilled water, at the temperature of its greatest condensation which a vessel contains, be known, the capacity of that vessel will then be easily determined, since a given bulk of distilled water is known. On the other hand, if we determine by measure the actual contents of a vessel, we shall know immediately the number of *grammes* of water in a maximum state of condensation, which that vessel will contain. If the weight of water at any other temperature, which the vessel contains, be ascertained, the weight which it would contain at the temperature of maximum condensation may be easily determined by the aid of the tables for the dilatation of water at different temperatures."—*Lardner's Cabinet Cyclopædia, Art. Heat.* vol. 39, pp. 76—79.

ERRATA.

Page. Line.

26, 7, from below, *for* "this however," read "this being however."
27, 8, before "that the," *insert* "again, can it be doubted."
31, 8, from below, *for* "eight," *read* "eighth."
32, 2, from below, *for* "karikia," *read* "karika."
33, 15, from below, *for* "Bat," *read* "Bath."
35, 14, *for* "Minshen," *read* "Minsheu."
36, 3, *for* "Minshen," *read* "Minsheu."
39, 7, after "ounce," *insert* "or 218·75 grains."
50, 2, *for* "phenomenon," *read* "a phenomena."
18, *for* "inspection," *read* "an inspection."
64, 8, *for* "or it may be revised," *read* "or, it may be, revived."
72, 2, from below, *for* "on the," *read* "and on the."
83, 3, *for* "or square cubits," *read* "or 13609·5556 square cubits."
86, 18, *for* "indebted for," *read* "indebted to the patriarchs for."
20, *for* "from the Jews," *read* "from their descendants the Jews."
88, 4, from below, *for* "the freedom," *read* "that the freedom."